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ENGINEERING

An Illustrated Weekly Journal

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ENERGY FOR BRITAIN

THERE are some subjects of universal significance which give endless opportunities to speakers and writers, but because responsibility for them is widely spread, effective action is rarer than solemn pronouncement. The prevention of war and the supply of food for an increasing population are two favoured topics. A third is the supply of energy in the future, in relation to the expansion of the world's needs and the gradual exhaustion of some of the principal natural sources. The facts are frequently presented in terms which are intended to cause alarm, but as it is unnatural to be alarmed about a calamity which is expected to occur several generations hence, it is not surprising that the warnings have only a gradual effect. But the subject of energy sources can be shown to bear directly on contemporary work and thought, and opportunities for present-day action can often be indicated.

That is precisely what Dr. W. Idris Jones achieved in his presidential address to the Institute of Fuel delivered earlier this month. As Director-General of Research to the National Coal Board he is concerned primarily with coal, but his survey covered the likely sources of energy for Britain in the decades ahead. Never before, surely, have research workers and engineers devoted so much attention to methods and techniques which are not likely to become commercially suitable for some years. Nuclear energy, solar energy, wind power, tidal power, fuel cells – all may make a useful contribution when relative costs have changed. The relative costs of different energy sources are changing slowly, and the change gives rise to opportunities in the design of new plant and equipment, and in many other ways.

The changes in the coal mines since the war are familiar. Dr. Jones foresees the difficulty of finding 300,000 juveniles and young men during the next ten to fifteen years. There will be an increasing demand for planning and production engineers, and there will be improvements in the environmental conditions of underground workers, more and better coal-face mechanisation, more power loading and stowing of waste material, more prop-free front faces, better underground transport (possibly using hydraulic transport of coal), more coal-winning shifts, and improved underground road-making and rock-handling machines. A 100 years from now the great new coalfields will probably be the Warwickshire-Staffordshire-South Derbyshire basin, the easterly extensions of the East Midlands and Yorkshire coalfields and the Firth of Forth under-sea coalfield. There will be changes also in the use of coal. Dr. Jones points out that the average efficiency of industrial steam boilers could be raised now from 50 per cent. to 65 per cent. by improvements in design and operation. The 120,000 Lancashire boilers are likely to be replaced by Economic and water-tube boilers in order to save space and money, and back-pressure generation of electricity will become more widespread as its economy in industries using process steam is appreciated.

In the year 2000, Dr. Jones forecasts, British Railways will be running their locomotives at an average efficiency of 10 to 15 per cent., instead of the present 7 per cent. This will not be achieved by improvements in the steam locomotive, but by extending the mileage of electrified track, by using more Diesel shunting locomotives, and possibly by employing gas-turbine locomotives. Steam locomotives will be equipped to burn small graded coal – presumably because the railways will not be able to obtain any other – but this, in itself, is not likely to affect the efficiency of operation. The average efficiency of power stations will rise from about 22 per cent. to 32 per cent. Generators of up to 180 or 200 MW unit capacity will be quite common and more than three-quarters of the coal fed to power-station boilers will be pulverised fuel. A marginal contribution to electric power production may be expected from hydro-electric and tidal-power plants (equivalent, Dr. Jones estimates, to about 6,000,000 tons of coal), and wind power may provide the equivalent of a million tons of coal. Nuclear power will probably contribute "very acceptable amounts." These sources of energy, however, will only compensate for the increasing power demand in Britain, and therefore coal will remain just as important in A.D. 2000 as it is to-day.

"An enormous and accelerated rate of capital investment" is visualised by Dr. Jones as giving effect to these and similar changes. That is, perhaps, the economist's or the politician's interpretation; the engineer's interpretation, as he suggests, is that the changes will demand more training, adequate technical and scientific knowledge, research and development work. "More people, from directors and managers downwards, must become more conversant with fuel and energy usage. . . . The next 50 years or so will present a great challenge to men of foresight, courage, adaptability and creativeness" His appeal is not solely to altruism or patriotism; it is to the realisation that there is scope for new designs, new applications and greater operating efficiency.

Weekly Survey

SELLING ELECTRICITY

Between the wars the British Electrical Development Association energetically pursued a policy of encouraging the greater use of electricity, especially for domestic purposes. These activities naturally came to an end in 1939 and after 1945 they were not at once resumed, owing to the shortage of generating plant, difficulties in the supply of fuel and a ban on promotional advertising. These obstacles have now been removed so that, to quote from a speech delivered by Dame Caroline Haslett at a conference reported on page 524 of this issue, the industry has now emerged from the dark tunnel of frustration into the sunshine of opportunity. This emergence, however, imposes its own problems, among which the training of staff to carry out the work of propaganda is the most important.

The scheme adopted by the Southern Electricity Board for a joint engineering and commercial apprenticeship is worth close attention. Such pupils would be able to meet industrialists on their own ground and impart information with the conviction that comes from sound technical knowledge. Hardly less important is the continuing need for equipment which is efficient and safe even when it is handled by the electrically unskilled. The testing house which has been established by the Association and is now becoming operative should be useful in influencing the design of apparatus, as is already shown by the lists of reliable appliances which the Ministry of Fuel and Power use for informing local authorities. Both these activities should assist in improving the national load factor which, as Sir Henry Self pointed out, has shown a tendency to droop. In this way the consumer will benefit from the higher efficiency of new generating plant (a note on page 518 reports that, for the first time, three power stations show an efficiency of over 30 per cent.).

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AIR POWER

Marshal of the Royal Air Force Sir John Slessor, addressing the Royal United Service Institution on April 14, said that although the development of the atom and hydrogen bombs had rendered the possibility of a future total war remote, the Western powers must be prepared for further minor aggressions. Reviewing air power in the past, Sir John said that before 1939 there was no real basis of experience on which to plan air warfare. The potentialities of the bomber had been over-rated initially, but in the long run, when the proper equipment was available in sufficient numbers, the effects of air bombing did fulfill the Air Staff's estimates.

Since the second World War there had been a revolution in human affairs brought about by atomic weapons. There was a general recognition that the use of such weapons could not possibly ensure a more favourable world situation for the victors. A total war would mean that weapons of mass destruction would be used by both sides, resulting in a series of immediate catastrophes. It would be mutual suicide. This depended on the assumption, which he believed to be true, that no effective large-scale defence against nuclear weapons was economically feasible, even if it were physically possible.

The Western powers, however, must be prepared to meet limited aggression and to make it clear that they were prepared. It was therefore necessary to have a strong and efficient regular army to man frontiers against infiltration, and to have a bomber fleet equipped to put down bombs where they were required ; in particular, the long-range un-manned bomber aircraft was called for. It was vitally necessary to protect sea ports, to disperse unloading facilities, and to increase the productivity of our own land so that we were not dependent on seaborne supplies. He would like to see the Royal Navy adequately supplied with reconnaisance aircraft for convoy escort, with more and better surface anti-submarine craft, and with anti-aircraft cover for convoys at sea.

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NATIONAL LABORATORIES

A recent report by the Standing Commission on Museums and Galleries (which covers the period 1949-53) reveals a state of affairs which, to quote *The Times*, " must be extremely disturbing to anyone who is at all deeply concerned with the intellectual equipment of the nation." At the British Museum the staff is inadequate, the result being that cataloguing in the famous library is sadly in arrears and in several departments serious deterioration of the specimens is taking place. " The same discreditable story of lack of funds and of staff is told about many " other smaller institutions.

It was while pondering on the position thus disclosed that we listened to a speech by Sir Edward Bullard, Director of the National Physical Laboratory, at the opening of an extension to the metallurgy division of that institution on Tuesday, April 6. He recalled that, except for wind tunnels, no new buildings had been erected at Teddington since 1936; and that some of the activities of the Laboratory were still accommodated in Eighteenth Century buildings. It need hardly be stated that these buildings were not originally intended for the purposes for which they are now being used. He expressed the hope, which we share, that it will not be long before some improvement in this situation takes place.

From the account we give on page 520 of the development of metallurgical research at the National Physical Laboratory during the past fifty years no doubt can arise about the value of the work that has been done. It is, however, interesting to speculate upon the extent to which inadequate accommodation has hampered these researches; and whether these are not good reasons, some of which are psychological, for an examination of the whole question of housing in such institutions.

No one, especially in these abstemious days, advocates lavishness, but it is possible to go too far in the other direction. In fact, there would seem to be a case for the gradual replacement of old by new buildings adequately equipped and serviced, especially at such institutions as that at Teddington. The expenditure would be relatively small and the results would be well worth while. For a laboratory is as much a part of the intellectual equipment of a nation as a museum.

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MAINTAINING INITIATIVE

There is always a risk after a man has been in industry for a few years, that he may become merely a follower of routine. He will have learnt the traditional methods used by his firm and will have become accustomed to their ways and practices. After that, unless he makes a very considerable personal effort to keep up his reading in subjects allied to his own, he may well be unaware of developments which could usefully be adapted to his particular need. This danger applies both to production and research, though perhaps more particularly to the latter.

In order to keep up to date with developments, conferences and " summer schools " are held. Elsewhere in this issue particulars are given of a course running at Birmingham University which caters particularly for the graduate who has been some years in industry. This course lasts a year, but only nine months need be spent actually at the University, the remaining three being occupied by the preparation of reports on the work done. The student is given an intensive course in thermodynamics and related studies designed to enlarge his knowledge of modern developments in the many branches of mechanical engineering. An illustrated booklet describing the course is issued by the Mechanical Engineering department of the University and can be obtained from them. The University authorities have decided that from this year, successful completion of the course will qualify the student for the degree of Master of Science.

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FIRE-FIGHTING

The speaker at the April luncheon of the Old Centralians was Mr. F. W. Delve, C.B.E., Chief Officer of the London Fire Brigade. In his opening remarks, he outlined the position of the fire-fighting service as it was before the war; there were some 1,450 local organisations and 60 in the London area. This caused many difficulties when combined action was necessary. The question of fire protection during war was first discussed by a committee set up in 1936, which used the 1-kilogram incendiary bomb as the unit for basing plans. It was known at that time that Germany was preparing an enormous stock of these bombs and it was estimated that a single plane could carry over 2,000 of them.

Trials were conducted on models to find out what proportion of the bombs dropped would cause fires when they landed in areas built up to varying degrees. From these trials it was estimated that, in a fully built-up area, ten bombs in every hundred would fall on a roof and eight of these would cause fires. It was therefore quite probable that there would be 1,000 fires started almost simultaneously. In view of these predictions, and also considering that war was by no means certain at that time, it was decided that the trailer pump would be the best unit to concentrate upon. In built-up areas, the allocation was one every half-mile; this was reduced for rural areas to one every two miles or more. In the event, there was no shortage of equipment, but the pumps were hardly robust enough for the service demanded of them. Moreover, difficulty was experienced in obtaining sufficient water, due to fracture of the mains by high-explosive bombs. Of the 60 brigades in the London area only two had interchangeable equipment. This and other difficulties were cleared up by the Act of nationalisation.

Mr. Delve showed a film taken during the raid on the City of London on December 29/30, 1940. This was the first concentrated fire raid, and about 200,000 bombs were dropped in four hours, starting some 2,500 fires. " Fire-storm " conditions arose when the rate of propagation of the fire was faster than a man could run. It was this raid, and those in the following spring, which led directly to nationalisation. Plans for the future were being laid, he said, on the experiences of the past. Mistakes would be rectified as far as possible and preparations increased to meet the greater difficulties of the atom bomb. Now, with the hydrogen bomb to be considered, preparations would again have to be revised.

Letters to the Editor

ELECTRIC POWER LINK BETWEEN BRITAIN AND FRANCE

Low Marginal Cost of Hydro-Electric Stations

SIR, The transcript of the paper by Mr. D. P. Sayers, Mr. M. E. Laborde and Mr. F. J. Lane on page 464 of your issue of April 9 gives, in Fig. 1, curves of the maximum monthly demand on the British and French electric power systems. The shape of these curves suggests that the economic advantages of intercommunication between the two systems may extend beyond the possibilities now under discussion, which mostly arise from diversity between the two systems.

The French curve is very much smoother, much less peaky than the British; and 55 per cent. of the French energy comes from hydro-electric sources. This suggests that there may be economies in installing additional kilowatts of hydro-electric generating plant in France, to meet the narrow, short-duration peaks of the British system owing to the lower capital cost of installing a given number of extra kilowatts in a hydro-electric station than a steam station.

My figures are fifteen or twenty years old, and drawn from a particular case, but in connection with arrangements between the North Wales Power Company and the Central Electricity Board we used to calculate that, with a given quantity of kilowatt-hours available – determined of course by the watershed area, rainfall and head – it was possible to increase the kilowatts installed at a marginal cost of less than £8 per kilowatt. Since in those days steam capacity cost about £20 per kilowatt, there was (subject to obvious limitations) a potential saving of £12 per kilowatt in installing extra capacity to meet the top peak demand in a hydro station, rather than in a steam station. At to-day's price levels, presumably the differential would be £30 to £35 per kilowatt.

The capital cost per kilowatt of transfer capacity is quoted in the paper at £29 on a 275-kV basis. No doubt with bigger blocks to be transferred this figure could be reduced. If this is so, it looks as though there might be an economic possibility in transferring perhaps thousands of megawatts of British peak-load demand from the British (mainly steam) system to the French (mainly hydro) system at a gross capital saving of perhaps £10,000 per megawatt.

Yours faithfully,

GEORGE WANSBROUGH.

Yeoman Vehicles, Limited,
London, S.W.1.
April 13, 1954.

PREVENTIVE MAINTENANCE OF OIL ENGINES

SIR, Your issue of April 2 gave an extract from my paper "Preventive Maintenance from Breakdown Experience." I wish you to correct a misprint on page 428, paragraph 2, which reads as follows: "When a piston is hot, it becomes oval and the pin is liable to keep it in this position; tapping the pin on the opposite end will often relieve this strain." "When the piston is hot" should read "When the piston is hit."

I mention this error as in my opinion distortion of pistons due to faulty assembly has caused many seizures and some disastrous crank-chamber explosions.

Yours faithfully,

H. D. ADAM.

85 Gracechurch Street,
London, E.C.3.
April 9, 1954.

NON-DESTRUCTIVE TESTING

Institute of Physics Meeting

With the appearance of new techniques for proving or sorting materials and components, some of which are complementary to radiography, the Industrial Radiology Group of the Institute of Physics has inevitably developed an interest in them. The Group has accordingly been reconstituted, with extended powers of reference, and will be known in future as the Non-Destructive Testing Group. In conjunction with the Midland Branch of the Institute, the new Group is arranging a summer meeting at the Chancellor's Hall, University of Birmingham, from Wednesday, July 7, to Saturday, July 10, 1954, on a wider field of physical methods of non-destructive testing than on previous occasions.

The meeting will be opened with an informal reception on the Wednesday evening, when, after dinner, there will be an address by Professor A. J. Murphy, professor of industrial metallurgy at Birmingham University. On Thursday, two hours will be devoted to a forum on questions concerning the scope and limitations of non-destructive testing, at which the panel will comprise Mr. A. H. Goodger, Mr. S. H. Griffiths, Dr. R. F. Hanstock, Mr. G. T. Harris and Dr. H. Harris. Other sessions to be held on that day will deal with isotope techniques, image intensifiers and diffraction mottling, at which the speakers will be Mr. R. Halmshaw, Dr. A. Nemet, Dr. J. R. Rait and Mr. H. S. Peiser.

On Friday, there will be a session on the theory and application of electrical and magnetic methods of non-destructive testing, at which Dr. E. G. Stanford, Mr. H. W. Taylor, Mr. L. T. Perriam and Mr. R. H. Wallace will speak. On Saturday, there will be a session on the propagation of elastic waves in solids and another on selected topics in ultrasonic testing, when the speakers will be Dr. H. Kolsky and Mr. J. D. Hislop, respectively.

The meeting will be open to all interested persons and further particulars may be obtained from the deputy secretary, Institute of Physics, 47 Belgrave-square, London, S.W.1.

* * *

DERAILMENT OF AN EXPRESS TRAIN

"Hunting" of Engine

"Neither the faults in the engine or tender, nor those in the track were such as to be dangerous in themselves . . . and the train would have passed safely over the track if it had been going a little slower or a little faster, or if the engine had been pulling harder. Nevertheless, a critical combination of the effects of these faults gave rise to this derailment." With these words the inspector of railways, Colonel W. P. Reed, has summarised his findings on the derailment of the express passenger train from Bradford to Bristol between Wilnecote and Kingsbury, Warwickshire, on August 17, 1953.*

The train, comprising nine coaches drawn by a 4-6-0 type engine of the "Royal Scot" class, was completely derailed when travelling at 55 m.p.h. on plain straight track. Though the day was fine the inspector was able to satisfy himself that there had been no heat distortion of the track. Classified as a Class A line, a maximum speed of 75 m.p.h. is permitted on it and at the point of the accident the track, the down line, is rising on a gradient of 1 in 460 on a straight alignment in a deep earth cutting. The rear seven coaches of the train were derailed to the left but remained coupled together, with the leading coach 153 yards and the rear of the last coach 12 yards ahead of a severed rail joint just beyond the first mark of derailment. The front portion of the train, comprising the engine, tender and two coaches, came to rest a clear 116 yards ahead of the rear part, having just passed a diamond crossing and clip connection leading from local sidings to the up line. All the couplings between the engine, the tender and two coaches were unbroken, though the engine had turned on to its left side and the tender was pointing to the right, tilted to the left at approximately 30 deg. to the horizontal; the coaches remained upright but the underframes and bogies of both, particularly the leading coach, were severely damaged. The engine was little damaged and it was clear that it had not fallen on to its side until the last few yards of travel.

* *Railway Accidents; Report on the Derailment between Wilnecote and Kingsbury, London Midland Region.* H.M. Stationery Office, Kingsway, London, W.C.2. [2*s.* 6*d.*]

SIGNIFICANT VARIATIONS IN CROSS-FALLS

The track consisted of 95 lb. per yd. bull-head rails laid on timber sleepers; both the rails and sleepers were nearing the end of their lives and proposals had been made for renewal in 1955. The track was well ballasted with broken stone and had been drained, cleaned and re-stoned as recently as 1951. Special measures had been adopted to maintain the track gauge though evidence suggested that close attention to cross-falls had been lacking. The diamond crossing and single slip into the sidings had been relaid in 1951 with 109 lb. flat-bottom rails as part of a renewal programme which included the up line in this locality. Though the crossing generally and the slip connection had suffered much damage, the flat-bottom track had withstood the impacts of derailed vehicles much better than the adjacent bull-head track. On the evidence of the scoring of the track the inspector was able to construct a comprehensive account of the derailment.

The immediate cause of the accident, he concluded, was "hunting" of the engine. That is to say, the engine had become subject to a compound motion consisting of a transverse oscillation of the engine on the track about a vertical axis together with a transverse oscillation of the engine on its springs about a longitudinal centre line. He satisfied himself that the engine was hunting on the approach to the point of derailment (the severed rail joint) and for some distance past it, and that this hunting distorted the track. The original cause of the hunting was partly a significant variation in cross levels about 500 yards before the derailment, followed by lesser variations in cross falls which coincided in their effect with the natural hunting period of the engine, and partly an uneven loading of the engine bogie and coupled wheels, which, combined with side play in the tender axles, made the train less stable.

This account of the accident was at variance with the evidence of the engine driver, who maintained that there had been no lurching or rough riding of the engine until the final seconds before the engine overturned. He did, however, agree that he had felt a "drag on the engine" which had caused him to apply the brake in the belief that part of the train was derailed.

Finally the inspector reports that, though in neither case were the shortcomings of the track or rolling stock sufficient to be dangerous in themselves, in both cases they were of such a magnitude that they should have been seen and corrected by the staff concerned. Taken separately they may not have seemed important, but when considered conjointly their significance became apparent and, in conjunction with the unfortunate critical speed of the train, were the cause of the derailment.

THE INSTITUTE OF BRITISH FOUNDRYMEN

The Jubilee Banquet

When proposing the toast of the Institute of British Foundrymen at the jubilee banquet held in London on April 9, Brigadier A. R. W. Low, C.B.E., D.S.O., M.P., Parliamentary Secretary, Ministry of Supply, said that the Institute had grown and prospered during the 50 years of its existence because it had translated the results of scientific research into practice and had fostered their adoption on the foundry floor.

In his response, the President, Mr. E. Longden, said that scientific and learned associations like the Institute did much towards international understanding and led to co-operation between technical men. Far from being satisfied, however, with the progress made as a result of collaboration between craftsmanship and science, the Institute must continue its work. It might be of interest to consider the next 50 years, during which substantial developments in atomic power might be expected. Cheap and abundant supplies of electricity would lead to many economies in the foundry industry and might also help to develop new alloys.

In proposing the the toast of "Kindred Associations at Home and Abroad," Mr. John Bell, the senior vice-president of the Institute, mentioned that Mr. F. W. E. Spies, President of the Netherlands Foundry Technical Association and a past-president of the International Committee of Foundry Technical Associations, had just been elected an honorary member of the Institute. Mr. Spies, in reply to this toast, said that it had been as a result of attending technical meetings of foundrymen and visits to foundries that the Dutch industry had been encouraged to found a scientific research organisation on the lines of the British Cast Iron Research Association and the British Non-Ferrous Metals Research Association. Such an organisation did not exist in the Netherlands before the war.

The toast of the guests was proposed by Mr. M. M. Hallet, President of the Sheffield branch of the Institute and replied to by Sir Archibald Forbes, chairman of the Iron and Steel Board. The last toast of the evening, that of "The Secretary" (Mr. T. Makemson, M.B.E.), was proposed by Mr. N. P. Newman, J.P., a past-president and the hon. treasurer of the Institute and also chairman of the Council of Ironfoundry Associations. He said that when Mr. Makemson had taken up the position of secretary in 1926, there were 1,600 members. At the present time the membership stood at 5,300. In the course of his reply, Mr. Makemson said that before the formation of the Institute foundries were merely adjuncts to engineering and other firms. By the efforts of the Institute, however, persons engaged in founding had become conscious that they belonged to an industry worthy of standing on its own feet.

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RUBBER-LIKE COMPOUND FOR CONTAINERS

The Dunlop Rubber Co. Ltd., now make a light flexible compound which may be used for producing a wide range of containers for factory use. Fortiflex is resistant to vegetable fats and low-concentration acids and alkalis, is easily washed and is produced in a standard thickness of $\frac{1}{8}$ in. The flexibility of the material enables the containers made from it to maintain their shape under rough treatment, and these include round bins for storing dry or liquid compounds or waste material, trays for the rack storage of small metal parts, buckets, etc.

TRENDS IN MARINE DESIGN

REPORT OF LLOYD'S REGISTER

Current tendencies in ship design and marine engineering are among the subjects discussed in the Annual Report for 1953 of Lloyd's Register of Shipping, 71 Fenchurch-street, London, E.C.3. The report also comments on research undertaken or completed during the year, announces revisions in the Society's Unified Rules, lists ships classified in 1953 and provides, in the form of tables, analyses of world shipping distribution in terms of vessel age, percentage of tankers, means of propulsion and type of fuel employed. It is reported in addition that a special contracts department has been formed to deal with non-marine work accepted by the Society, which in 1954 is to include supervision of the construction of two atomic energy power plants.

STRUCTURAL STRENGTH

In the field of marine design, it has been observed that dry cargo ships are being built with higher speeds and power ratings; this has tended to cause an appreciable increase of hogging bending moment when such ships are subjected to heavy weather while in the loaded condition. The longer spaces for machinery amidships and for cargo in forecastles and poops are largely responsible for this effect and, moreover, it is possible with present engine powers for ships to be driven too hard in bad weather.

Consequently, it is expected that the trend in design will be towards judicious distribution of cargo and fuel load with the object of minimising longitudinal stress. Special care will be taken in the locating of machinery spaces; and load concentrations at the extreme ends of ships will be avoided.

In the report it is recommended that longitudinal framing should be used in modern cargo ships as a means of increasing structural efficiency; in current construction such framing is rapidly becoming general practice. The Society has appointed a panel to investigate the problem of structural failure, which has become a subject of special importance since the loss at the close of 1953 of a comparatively new ship due to this cause.

GAS TURBINES AND FREE-PISTON ENGINES

Recent developments in marine power-plant engineering include the growing use of gas turbines for propulsion and other purposes. Gas-turbine propelling machinery is to be installed in a tanker for the Shell Petroleum Company. Cargo liners under construction for Alfred Holt and Company are to have gas-turbine driven emergency generators.

Interest has been shown in the Pescara free-piston engine, which, operating in conjunction with gas turbines, has been installed in a French coaster. The Society was represented at trials of the vessel held last year. The British Commonwealth agents for the engine are Alan Muntz and Company, Limited, Heston Airport, Hounslow, Middlesex.

"DELTIC" ENGINE

Plans of the "Deltic" engine, which was described on page 555 of our issue of May 1, 1953, have now been approved by the Society. It is made by D. Napier and Son, Limited, 211, The Vale, London, W.3, and is a three-crankshaft triangular two-stroke opposed-piston high-speed oil engine developing 1,725 h.p. and weighing little more than 4½ tons including the reversing gear. Although it has been produced primarily for naval purposes, it will probably be employed eventually in merchant ships, where it will present special problems of maintenance.

Renewed interest in the geared steam turbine has drawn attention to the principles of gear design and manufacture. Study of materials and the manner of surface-finishing gear teeth have revealed the possibility in certain circumstances of increasing tooth loading and hence of achieving an appreciable saving in weight.

BRITTLE FRACTURE AND CORROSION

Research during the year has been devoted largely to the study of notch toughness in steels and the problem of corrosion. The Society has collaborated with such bodies as the Admiralty Ship Welding Committee in seeking a satisfactory mechanical test to assess the liability of steels to brittle fracture, and efforts to select such a test are proceeding. The onset of corrosion is found to be influenced by modern shipbuilding methods which permit insufficient time for the full weathering of the steel. The complete removal of mill scale and correct initial coating of the steelwork in new ships remain the best protection against corrosive attack.

The rapid internal corrosion peculiar to tankers is also being investigated and several processes to prevent it are undergoing trial. It is considered possible that the large proportions of crude oil being carried at present may contribute towards the pitting on the inside of the bottom plates but this has yet to be ascertained.

The owners of an ore carrier under construction in Canada propose that their ship be fitted with aluminium bilge, ballast and oil-fuel piping, to gain experience concerning the behaviour of aluminium when used for such services on ships.

HULL VIBRATION

Methods of defeating hull vibration have included the application of a correctly designed and phased balance weight to the intermediate shafting in way of the aftermost shaft bearing of a ship in which the problem had proved serious. No keys were employed to locate the weight, which was secured to the shaft by a friction grip alone.

Valuable results have been obtained from the measurement under service conditions of tail-shaft and propellor-blade stresses by means of electric resistance strain gauges and slip rings. Two different types of ship, both prone to tail-shaft failure, have been tested in this way.

HEAT FROM REFRIGERATION PLANT

Both the heating and normal cooling for the air-conditioning system of a new passenger ship are to be provided by a single refrigeration plant. When heat is to be supplied, the machinery operates on a reversed cycle, drawing heat from the sea and transferring it to the ship through the compression and liquefaction of the refrigerant, like a heat pump.

ATOMIC ENERGY POWER PLANTS

The expansion of the Society's non-marine work has led to the formation of a special contracts department, which is to supervise, among other undertakings, the construction of two identical atomic energy power plants to be built in England for the generation of electric power. The work is to commence during 1954 and will, it is estimated, be completed in approximately three years.

OBITUARY

MR. A. E. HADLEY

Electric Power Supply in the Transvaal

Mr. A. E. Hadley, who died at Darsham, Suffolk, on Thursday, April 8, at the age of 83, for some years played a leading part in the development of electricity supply in the Transvaal as chairman of the Victoria Falls and Transvaal Power Company.

Arthur Edward Hadley was born on December 5, 1870, and was educated at Charterhouse. He then joined the firm of Ferranti, Limited, who have played so large a part in electrical progress, being engaged in that firm's laboratories at Hollinwood. He subsequently began to practice in London as a consulting engineer and established a sound reputation as a business adviser, as is shown by the invitations he received to join the boards of the City of London Electric Lighting Company and the Victoria Falls and Transvaal Power Company. He became chairman and managing director of the latter concern, positions from which he retired a few years ago.

During the 1914-18 war he acted as an assistant controller in the Inspection Department of the Ministry of Munitions and was made a Commander of the Order of the British Empire for his services. Subsequently he was chairman of Rhodesia Railways, Limited, and a director of the British South Africa Company.

Mr. Hadley was elected an associate of the Institution of Electrical Engineers in 1895 and was transferred to the class of members in 1912. A year later he read a paper on "Power Supply by Compressed Air on the Rand," for which he was awarded an Institution Premium.

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MR. A. W. S. CLARKE

Aircraft Design Engineer

We record with regret the death of Mr. A. W. S. Clarke, chief engineer of Short Brothers and Harland, Limited, which occurred on Monday, April 12, at his home in Northern Ireland.

Alan William Scott Clarke was born on April 7, 1897. He was educated at the Mathematical School, Rochester, and at the City and Guilds Technical College. In 1914 he joined Short Brothers, Limited, and remained with the company when it became merged with the associate company, Short Brothers and Harland, Limited, and was transferred from Rochester to Belfast. During his 40 years with the company he was closely connected with the design of many well-known aircraft, and was noted in the industry for his straightforward and outspoken attitude in dealing with his colleagues, and his generosity in helping them out of their difficulties. In 1932 he was appointed assistant designer in charge of the detail design of the Sarafand six-engine flying boat, at that time the largest aircraft to be built in the United Kingdom. He was appointed chief engineer in 1949. He became an associate fellow of the Royal Aeronautical Society in 1946.

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PERSONAL

Sir John Hacking, M.I.E.E., has been elected President of the British Electrical Development Association, 2 Savoy Hill, London, W.C.2, in succession to Sir Henry Self, K.C.B., K.C.M.G., B.Sc., B.A., M.Sc. Sir Harry Railing, M.I.E.E., has been elected a vice-president, and Dame Caroline Haslett, Lord Beveridge and Captain J. M. Donaldson have been re-appointed vice-presidents for a period of three years. Mr. S. F. Steward, C.B.E., M.I.Prod.E., chairman of the S.W. Electricity Board has been appointed chairman of the Council. Next year's vice-chairman will be Mr. C. R. King, C.B.E., chairman of the East Midlands Electricity Board.

Dr. T. W. F. Brown, director of the P.A.M.E.T.R.A.D.A. research establishment, Wallsend-on-Tyne, and Dr. A. T. Bowden, chief research engineer, C. A. Parsons & Co. Ltd., Heaton Works, Newcastle-upon-Tyne, have been awarded jointly the James Clayton Prize for 1953 by the Institution of Mechanical Engineers. Dr. Bowden has also been awarded the Thomas Hawksley Gold Medal by the Institution and Dr. Brown delivered the Thomas Lowe Gray lecture for 1953. The awards are to be made at the Institution in London to-day, April 23.

Sir William Wallace, C.B.E., F.R.S.E., M.I.Mech.E., M.I.N.A., chairman and managing director of Brown Bros. & Co. Ltd., Rosebank Ironworks, Edinburgh, has been awarded the Churchill Gold Medal by the Society of Engineers, 17 Victoria-street, London, S.W.1, for his part in bringing the Denny-Brown ship-stabilising gear into practical application. The Churchill Gold Medal was instituted 18 months ago and the first award was made to Air Commodore Sir Frank Whittle, F.R.S.

Mr. J. T. Moore, B.Sc., A.R.T.C., M.I.C.E., M.I.Mech.E., M.I.E.E., A.M.I.Mar.E., F.R.S.A., chief engineer of the English Electric Co. Ltd., is relinquishing his position this month to take up a directorship with Ewbank and Partners, Ltd., engineering consultants, 10 Grosvenor-place, London, S.W.1.

Air Vice-Marshal C. E. H. Allen, C.B., D.F.C., B.A.(Cantab.), M.I.Mech.E., has joined the aviation division of the Dunlop Rubber Co. Ltd., as liaison officer with the Ministry of Supply, the Air Ministry and aircraft firms. Mr. S. A. Brazier, technical manager of the firm's general rubber-goods division, Manchester, has been appointed technical consultant of the division. Mr. A. B. Hadley, manager of the Dunlop factories in Stoke-on-Trent, has been appointed works director of the firm's factory at Benoni, South Africa.

Mr. H. F. Farmer, who has been closely associated with the design and production of electrical control gear for nearly 48 years, retired from the British Thomson-Houston Co., Ltd., Rugby, on April 9.

Mr. W. H. L. Hewitt is joining the board of A.K. Fans Ltd., 20 Upper Park-road, London, N.W.3, as from May 1, as technical director.

Mr. S. McCracken, Assoc.M.C.T., M.I.E.E., previously manager of the Belfast sub-office of the Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, is now director of Metropolitan-Vickers South Africa (Pty.) Ltd., and has sailed for South Africa. Mr. F. W. Cox, B.Sc.(Eng.), M.I.E.E., has succeeded Mr. McCracken as manager of the Belfast sub-office. Mr. J. A. Brooks, B.Sc.(Eng.), A.M.Inst.W., has been appointed superintendent of the firm's motor department.

Professor Sydney Goldstein, M.A., Ph.D. (Cantab.), F.R.Ae.S., F.R.S., who was, from 1945 until 1950, Professor of Applied Mathematics at Manchester University and is at present vice-president of the College of Technology, Haifa, Israel, and Dr. E. G. Fubini, who is on the staff of the Airborne Instruments Laboratory, Mineloa, Long Island, New York, U.S.A., have been appointed to be the first two Gordon McKay visiting lecturers on applied science at Harvard University, Cambridge, Massachusetts, U.S.A.

Mr. J. D. Stranks, A.F.R.Ae.S., chief experimental engineer to Hawker Aircraft Ltd., has been elected to the board of the company as works director.

Mr. J. P. H. Read, A.M.I.E.E., has been appointed chief engineer (machine section) of the Electric Construction Co. Ltd., Bushbury Works, Wolverhampton, in succession to Mr. W. J. Stay, who retired on March 31 after 47 years of service with the company. Mr. F. S. Handley has been appointed assistant chief engineer (machine section).

Mr. G. Buchanan, B.Sc., has been appointed principal surveyor to Lloyd's Register of Shipping at Sunderland, in succession to Mr. H. P. Urwin, who, as stated on page 421, *ante*, will succeed Mr. G. R. Edgar, M.Sc., as principal surveyor at Newcastle-upon-Tyne, when the latter retires on June 30.

Mr. J. F. Prince and Mr. A. E. Taylor, A.M.I.E.E., have been appointed deputies to Mr. T. G. Travis, sales manager, Witton Engineering Works, Birmingham, of the General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2. Mr. Prince is to be deputy for export sales and Mr. Taylor deputy for home sales.

Mr. G. E. Woodhead, works maintenance assistant, civil engineer's department, London Midland Region, British Railways, Euston, has been made district engineer for Derby (South).

Mr. J. F. Byfield has joined the board of S. N. Bridges & Co. Ltd., Bridges-place, Parsons Green-lane, London, S.W.6, members of the John Brown Group, as sales director.

Mr. D. D. Walker, M.A., managing director and secretary of Evershed & Vignoles Ltd., has been appointed a director of the Iron Trades Employers Insurance Association, Ltd., and Iron Trades Mutual Insurance Co. Ltd.

Mr. S. Cornthwaite has been appointed Midlands sales manager of Marryat & Scott Ltd., Wellington Works, Wellington-road South, Hounslow, Middlesex, and will operate from the office at 41 Waterstreet, Birmingham.

Mr. H. N. Norbury has been appointed sales manager of the Parsons Engineering Co. Ltd., Southampton.

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BUSINESS CHANGES

The address of the Glasgow office of the Hamworthy Engineering Co., Ltd., Poole, Dorset, and of British Combustion Equipment Ltd., has been changed to 163 St. Vincent-street, Glasgow, C.2. (Telephone: CENtral 7751.)

The Factory Department of the Ministry of Labour and National Service inform us that the address of their Electrical Branch has now been changed to 40-41 York-terrace, Regent's Park, London, N.W.1. (Telephone: MUSeum 5030.)

The French manufacturing and sales rights of the British range of aircraft fuel-system components, designed and produced by Flight Refuelling Ltd., Tarrant Rushton Airfield, Blandford, Dorset, have been granted to the Société Carburateur Zenith, Lyons, France. The agreement, however, does not include equipment for refuelling aircraft in flight.

On April 29 the offices of Chemical Engineering Wiltons Ltd., a subsidiary company of Simon-Carves Ltd., will be transferred to Cheadle Heath, Stockport, Cheshire. (Telephone: Gatley 5231.)

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CONTRACTS

Railway Wagons. The British Transport Commission have given an order to R. Y. Pickering & Co. Ltd., Wishaw, for 2,700 steel wagons, of the standard 16-ton mineral type. The order, valued at £750,000, is expected to take 2½ years to complete.

Television Studio Equipment. The British Broadcasting Corporation have placed contracts with Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex; Electric and Musical Industries Ltd., Hayes, Middlesex; and Pye Ltd., Cambridge, for television cameras, picture monitors and other equipment for studio use. The Marconi contract covers the provision of 16 cameras using the 4½-in. image Orthicon pick-up tube (developed for studio use and manufactured by the English Electric Valve Co.), the associated camera channel apparatus, six vision mixing and pre-view switching equipments, distribution amplifiers and wave-form generators. The E.M.I. contract covers the provision of 17 cameras of the improved C.P.S. Emitron type and the associated camera channel equipment. The order to Pye Ltd. involves the provision of 62 picture monitors. The equipment detailed above will be used to re-equip some of the existing television studios and to extend studio facilities in the London area.

Rock-Carrying Dumping Vehicles. A series of 17 model-14B 4½-cub. yd. Muir-Hill rock-carrying dumping vehicles have been ordered from E. Boydell & Co., Ltd., Old Trafford, Manchester, by the Main Roads Department of the Government of Norway.

Motor Buses. The Glasgow Corporation Transport Department have arranged to purchase 100 new motor buses to meet replacements in their present fleet and to provide additional vehicles to serve new housing areas. The cost will be £423,876. Orders for 50 chassis each have been placed with A.C.V. Sales Ltd., 49 Berkeley-square, London, W.1, and Transport Vehicles (Daimler) Ltd., Coventry. The contract for the bodies of the vehicles will also be divided, 50 going to W. Alexander and Co. (Coachbuilders) Ltd., Falkirk, and 50 to Metropolitan-Cammell-Weymann Ltd., Vickers House, Broadway, London, S.W.1.

WORK STUDY IN CHEMICAL FACTORIES

The proceedings of a Work Study Conference held last autumn in Buxton under the auspices of the Association of British Chemical Manufacturers, have now been published in book form, which is available, price 7*s.* 6*d.*, post free, to members of the Association, and 12*s.* 6*d.*, post free, to non-members. The book contains all the addresses delivered at the two-day conference and a summary of the main points which emerged at the meetings of the 13 discussion groups held. The Council of the Association are anxious that all possible help and advice should be given to firms who may wish to apply work-study schemes in their factories. To this end, a Work Study Advisory Committee has been appointed "to stimulate and encourage the application of work study in the chemical industry; to advise on problems arising therefrom; and to report periodically to the Council." The chairman of the Committee is Dr. D. E. Wheeler and the other members are Mr. N. H. Dennis, Dr. W. G. Hiscock, Mr. J. Grange Moore, and Mr. B. White. All communications should be addressed to the director of the Association, 86 Strand, London, W.C.2.

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POWDER METALLURGY

Symposium and Exhibition

Arrangements are being made by the Iron and Steel Institute, in association with the Institute of Metals, to hold a symposium on powder metallurgy at Church House, Great Smith-street, London, S.W.1, on Wednesday and Thursday, December 1 and 2, 1954. There will be morning and afternoon sessions on each of these days for the discussion of the papers, which will be divided into three main groups: metal powders and their assessment, research and production practice, and the production and properties of engineering materials. Both ferrous and non-ferrous aspects will be covered.

A small exhibition of powder-metallurgy components is being arranged in connection with the symposium. The papers, together with the proceedings and discussions, will be published in book form at a later date. Further information may be obtained from the secretary, Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1.

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PERIODICALS IN PATENT OFFICE LIBRARY

Bibliographies and Abstracts Provided

Immediate access to over 3,500 scientific and technical periodicals in all languages has been provided by a new extension to the Patent Office Library which is now open to the public in the basement of the headquarters building in Chancery-lane, London.

All of this periodical material, which ranges over the whole field of technical invention, will now be conveniently arranged on open shelves. It will cover items published since 1920, much of which has hitherto been available only on request. Earlier volumes will continue to be supplied on demand. An important addition will be the provision of a special section for bibliographies and abstracts.

The extension has been made possible by a general rearrangement of the library and by overhauling the war-time accumulation of unbound volumes. These arrears have been reduced from 22,000 to 14,000 in the past three years and will be further reduced to 10,000 by the end of this year.

The Patent Office Library is open to the public until 9 p.m. Monday to Friday, and until 5 p.m. on Saturday.

BRITISH ASSOCIATION MEETING AT OXFORD

Preliminary Programme

The annual meeting of the British Association is to be held in Oxford from September 1 to 8. Dr. E. D. Adrian is President and his address, which will be delivered at the Inaugural Meeting in the evening of Wednesday, September 1, will be on the subject of "Science and Human Nature." The preliminary programme for the meeting has now been issued to members, but can be obtained by prospective members from the offices of the Association at Burlington House, Piccadilly, London, W.1. Most of the sections, including Section G (Engineering), will commence their programmes on Thursday morning.

Dr. Willis Jackson, F.R.S., is this year's President of Section G and his address on "New Materials in Engineering" will be delivered on Friday morning. The detailed programme of the Section is not yet available, but the subjects to be considered include the efficient use of fuel, the engineer in management, vehicles and accidents, coast erosion and protection, cold forming and steel pressing, and the engineering aspects of printing. As is now a regular feature, one of the sessions will be devoted to the reading and discussion of papers by young engineers, and another welcome event, of less frequent occurrence in recent years, will be the holding of a sectional dinner in the evening of Monday, September 6. In addition to the general excursions, an interesting programme of visits to places of particular interest to engineers has been arranged by the officers of the Section, and there seems every reason to anticipate that the Oxford meeting will be at least as attractive as any held in recent years. Professor W. Fisher Cassie, of King's College, Newcastle-upon-Tyne, 1, is Recorder of the Engineering Section.

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THERMAL EFFICIENCIES OF BRITISH POWER STATIONS

The British Electricity Authority announce that the overall thermal efficiency of their 300 steam power stations in 1953 was 23·22 per cent., compared with 22·62 per cent. in 1952. This improvement represents a great saving of coal and an economy of over £3 million.

Of nearly 60,000 million kilowatt-hours sent out from steam stations during the year, one quarter was generated in the 20 most efficient stations, three of which attained an efficiency of over 30 per cent. for the first time. Those 20 stations had an average efficiency of just over 28 per cent., their individual efficiencies being:

Station	Thermal Efficiency, Per cent.
Portobello, high pressure, Edinburgh	30·86
Stourport B, Worcestershire	30·40
Dunstan BII, Newcastle-upon-Tyne	30·07
Littlebrook B, Dartford, Kent	29·68
Bromborough, Cheshire	29·10
Skelton Grange, Leeds	28·76
Brunswick Wharf, London	28·62
Braehead, Renfrew	28·61
North Tees C, Middlesbrough	28·53
Battersea B, London	28·24
Uskmouth, Newport, Mon.	28·21
Huncoat, Accrington	27·86
Poole, Dorset	27·46
Agecroft, high pressure, Salford	27·37
Staythorpe, Newark	26·71
Blackwall Point, London	26·63
Keadby, Scunthorpe	26·61
Stuart Street, high pressure, Manchester	26·52
Cliff Quay, Ipswich	26·49
Clyde's Mill, high pressure, Glasgow	26·42
Barking C, high pressure, London	28·62
Carrington, near Manchester	27·83
Littlebrook C, Dartford, Kent	27·65
Carmarthen Bay, Burry Port	27·53
Brighton B, Sussex	27·44

The last five stations did not come into operation until after January 1, 1953, but are included for purposes of comparison.

AN EXHIBITION OF "AUTOMATION"

Automatic Machines and Factories

Arrangements are being made to hold an international "automation" exposition, designed to appeal to engineers and executive officials interested in automatic machines and factories, at the 242nd Coast Artillery Armory, New York, during the week commencing Monday, November 29, 1954.

The exposition is intended to provide an opportunity for the constructors of automatic machinery and similar products to display the latest advances to engineers and others responsible for organising modern production methods.

Mr. Richard Rimbach, under whose direction the exhibition is being organised, defines "automation" as the use of automatic means, in association with some type of measurement, for controlling quality and reducing costs during production. The measurement, he states, may be based upon the direct measurement of any variable, or it may be the error signal representing deviation from a desired point of control.

Further information may be obtained from the First International "Automation" Exposition, 845 Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A. There is no registration fee.

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THE INSTITUTE OF FUEL

Annual Report for 1953

The total number of members on the roll of the Institute of Fuel on December 31, 1953, was 4,300, against 4,120 at the end of 1952. The Council of the Institute presented their annual report for the year ended December 31, 1953, at a meeting on April 8.

Dr. D. T. A. Townend, C.B.E., has continued to preside over the committee on education, to the strength of which have been added, during the year, Mr. W. N. C. Clinch, M.I.E.E., Dr. J. E. Garside, M.Sc.Tech., Captain (E) W. Gregson, R.N.R., and Dr. C. Whitworth. The qualifications sub-committee, consisting of Dr. Townend, Dr. G. E. Foxwell and Dr. L. V. W. Clark, has continued in active being, working mainly by correspondence on a greatly increased number of individual cases and on a general review of the list of qualifications recognised for complete or partial exemption from the Institute's examinations, upon which they are about to report. The Institute has also continued to work in close association with the City and Guilds Department of Technology.

The Council further state in their report that they are gratified to see the remarkable growth in strength and activity of the membership of the Australian section of the Institute. They add that the committees of all the sections have met regularly during the year and have had under constant review attendances at meetings of their sections. Arrangements in such matters as the timing of meetings and the structure of programmes vary from centre to centre. In all these matters, but particularly in making possible and encouraging the attendance of younger members, the Council trust that the influence and interest of senior members will be exercised to the utmost.

Successful meetings have taken place in all centres, and in October next a conference will be held to make a special study of the "Removal and Recovery of Sulphur from Fuels." This will constitute another of the series of studies on specific subjects which have proved, in past years, to be valuable and to have a wide appeal.

Book Reviews

PROFESSOR TIMOSHENKO'S PAPERS

The Collected Papers of Stephen P. Timoshenko. Arranged by E. L. ERIKSEN, J. N. GOODIER, J. P. DEN HARTOG, L. S. JACOBSEN, R. E. PETERSON and D. H. YOUNG. *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (140*s.*)

Few practising engineers ever have occasion to make bibliographical references in their original papers to text-books in their chosen field of study, though they often acquire fresh knowledge from periodicals and institution papers. The active front in most branches of engineering research is so far ahead of the territory already captured that references to the consolidated gains in text-books rarely appear in the records of current achievements. Yet the name of one author of text-books on engineering science often occurs in footnotes in the technical literature. The reason is not far to seek: his subject-matter is so authoritative and so well-arranged that it has come to be regarded not merely as the standard text on particular problems but also as an indispensable source of reference as much to professional engineers as to students. It will be good news to all these that the scientific papers of Professor Timoshenko have been collected together by a number of former students and colleagues, and published in a single volume.

The papers, amounting to 35 in all, are arranged in chronological order, and each is reprinted in the form in which it was first written, in English, French, or German. A considerable number of Professor Timoshenko's early papers, originally published in Russian, were later translated or abstracted into one of these languages, and thus incorporated into the present collection of his scientific contributions to the study of the strength of materials and allied subjects.

Several of the papers fall into main groups, of which one embraces the general principles of elastic stability, and the application of these principles to thick plates, the web of a plate girder, and to flat curved bars and slightly curved plates. This division into groups is, of course, quite arbitrary, since some of the separate sections of the work do not readily lend themselves to such classification, and of these the papers on the "Theory of Bending, Torsion and Buckling of Thin-Walled Members of Open Cross-section," and on "A Membrane analogy to Flexure," are two which the reader may equally well include in the group directed to the study of bending and twisting of bars, beams, shafts, and tubes. Other contributions which thus stand apart have to do with the torsion of crankshafts, the pendulum hardness tester, and the problem presented by a bi-metal thermostat.

A considerable part of the book contains information of special value to those in search of guidance on the distribution of stress in a plate pierced by a hole, or in components of other shapes with fillets, in a rectangular plate on the edges of which known normal tractions are applied, and in a circular ring compressed by forces acting along a diameter. There are also detailed discussions of questions relating to the deflection of a plate with the edges supported in different ways. Of the several papers dealing with vibration due to mechanical causes, that "On the Correction for Shearing of the Differential Equation for Transverse Vibrations of Prismatic Bars," deserves special notice because its implications are not so widely recognised as they should be.

Altogether, these papers are noteworthy for a wide application of the methods of classical mechanics, and, in particular, those associated with the names of Lagrange, Rayleigh, and Ritz. Extensive use is also made of trigonometrical series in the solution of important problems, as is shown in three papers with the following titles: "The Stiffness of Suspension Bridges," "Vibration of Bridges," and "Theory of Suspension Bridges." But the methods of engineering research are not confined to applications of mathematics. Nor is the book. It includes the paper on "Stress Concentration and Fatigue Failures," which was originally published in the *Proceedings* of the Institution of Mechanical Engineers. Finally, there is the background of a wide experience in engineering. The remarkable range of this experience and the attractive personality of Professor Timoshenko together provide the basis of the biographical sketch which Professor D. H. Young has contributed to the book.

Protective Atmospheres. By A. G. HOTCHKISS and H. M. WEBBER. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, U.S.A.* (7 *dols.*); *and Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (56*s.*)

It is for the purpose of preventing scaling in heat-treatment furnaces that the use of a protective atmosphere is most familiar in the engineering industries, but as the wide survey covered by this book shows, the principle of carrying out industrial operations in the presence of some selected gas, rather than atmospheric air, has now been extended to a wide variety of jobs, at least in the United States, with which the book is only concerned. For instance, exothermic gas, formed by the complete combustion of fuel gas and consisting mainly of carbon dioxide and nitrogen, is used to prevent the formation of scum and oxides on stored paints and varnishes. The same gas is used by some tyre manufacturers to prevent oxidation of the rubber during high-temperature-steam treatment. The use of a blanketing gas to extinguish fires is well known, but the handling of various organic dusts, capable of forming explosive mixtures, in an inert atmosphere, may be less familiar.

It is, however, the main part of this book, dealing with the heat treatment of metals, which will be of interest and importance to engineers. It was for the purpose of reducing, or eliminating, surface oxidation that furnaces with loosely-fitting doors were first replaced by those of gas-tight construction in which heat-treatment operations could be carried out in a controlled atmosphere. The method has now been extended and by the use of a reducing atmosphere containing hydrogen or carbon monoxide, oxidised steel surfaces may be reduced to pure iron; the process is used in the continuous galvanising of steel strip. Reducing atmospheres are also employed in sintering operations. Another important development is gas carburising for which natural gas (mostly CH_4) or propane (C_3H_8) are used and, finally, in this incomplete list, nitriding is carried out in an atmosphere containing from 25 to 70 per cent. of ammonia gas.

It is stated in the preface to this book that "it is not intended to be a scientific treatise on theory or on equipment design," none the less, sufficient information about the reactions taking place in the various operations described is given to enable the user to understand the broad principles of the processes under his control and the furnaces and other apparatus used are illustrated by diagrams and reproductions of drawings and photographs. The storage and handling of the large number of gases which are used for one purpose or another is dealt with in detail, with information about safety measures. It is doubtful if such a wide range of information about the use of protective atmospheres in industrial processes has ever been presented in a single volume before, and the book should appeal to executives in many, or even most, engineering shops. It is, as it is intended to be, a practical manual; this is well indicated by the final section, which is concerned with "what to look for and what to try if things go wrong."

BOOKS RECEIVED

Proceedings of the Work Study Conference, Buxton, October, 1953. *Association of British Chemical Manufacturers, Cecil Chambers, 86 Strand, London, W.C.2.* (Members, 7*s.* 6*d.*; non-members, 12*s.* 6*d.*)

Optical Workshop Principles. By CHARLES DÉVÉ. Translated from the French by THOMAS L. TIPPELL. Second English edition. *Hilger and Watts, Limited, 98 St. Pancras-way, Camden-road, London, N.W.1.* (42*s.*)

Protection against Betatron-Synchrotron Radiations up to 100 Million Electron Volts. United States National Bureau of Standards Handbook 55. *The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.* (25 cents.)

Proceedings of the Ankara Symposium on Arid Zone Hydrology. *United Nations Educational, Scientific and Cultural Organisation, 19 Avenue Kléber, Paris* (16e). (1,500 francs); and *H.M. Stationery Office, Kingsway, London, W.C.2.* (30*s.*)

Notes and Nomographs for the Design of Flat Rectangular Plates Under Normal Pressure. By GEORGE D. MOUAT. *The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey.* (3*s.*)

The British Journal Photographic Almanac, 1954. *Henry Greenwood and Company, Limited, 24 Wellington-street, Strand, London, W.C.2.* (5*s.*)

Sponge Iron and Direct-Iron Processes. By EDWARD P. BARRETT. United States Bureau of Mines Bulletin No. 519. *The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.* (1 dol.)

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TECHNIQUES OF METALLURGICAL RESEARCH

NEW CERAMICS, RADIOACTIVE TRACER AND X-RAY LABORATORIES AT TEDDINGTON

In the Annual Report of the National Physical Laboratory for 1901 it was stated that two rooms had been equipped in one of the wings of Bushy House for metallurgical work. This work was to be a continuation of the research carried out by Sir William Roberts-Austen at the Royal Mint on behalf of the Alloys Research Committee of the Institution of Mechanical Engineers and was to form part of the activities of the newly-formed Physics Department. One of the rooms was equipped for heat treatments and the other for the chemical analysis of metal samples, both being in charge of Dr. H. C. H. (afterwards Sir Harold) Carpenter.

The work of this section increased so rapidly that a new building was constructed in 1906-07, the space in it being equally divided between metallurgical and chemical laboratories. The old laboratories were then vacated and a Department of Metallurgy and Metallurgical Chemistry, with a staff of thirteen, was created. In 1910 a gift from Sir Julius Wernher enabled a further new building, consisting of a two-storey block attached to the end of the original single-storey structure to be erected, as well as a new wing comprising a machine shop and foundry. Three years later, by which time the staff had risen to about 30, a separate building was erected to house an experimental rolling mill and other equipment for the working of metals, while in 1921 a third storey was added to the Wernher building. A separate building was erected to the east of the rolling mill in 1931 to which the machine shop was transferred, thus enabling the original shop to be re-equipped as a laboratory for high-frequency induction furnaces.

During the past 25 years the guiding principle of the staff, which has fluctuated between 70 and 75, has been to maintain a balance of interest between ferrous and non-ferrous metallurgy, with results that are well known. Now the continuous development of techniques for the examination of the fine structure of metals and the growth of interest in the properties of materials at very high temperatures has led to a further extension of accommodation, which was formally opened by Sir Lawrence Bragg on Tuesday, April 6.

CERAMICS

The new building has two storeys and a total floor space of 11,700 sq. ft., of which about 5,800 sq. ft. is experimental working space. It is designed to accommodate three sections of the Metallurgy Division – the ceramics section, the X-ray section and a new radioactive tracer section.

The ceramics section is on the ground floor and consists of five laboratories and offices, as well as a furnace room. The section is mainly concerned with the development and production of refractory ware for use under exacting conditions, especially those involving very high temperatures. Two of the laboratories will be used for forming and drying the ware, and the furnace room will permit firing on a considerable scale. This room also contains machines for crushing and grinding, while space has been left for the needs of specialised experiments and measurements. The third laboratory is available for physico-chemical research on a smaller scale. Chemical benches and services have also been installed in the two offices so that they can be used for work of special delicacy. The development of methods for measuring the technically important physical properties of refractory materials at very high temperatures is expected to be one of the important functions of this section.

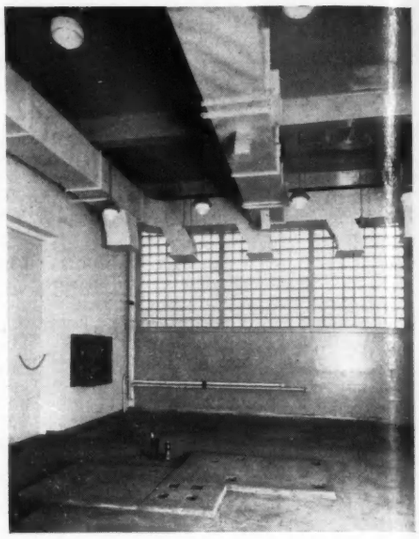
RADIOACTIVE TRACER

Three rooms on the ground floor are to be devoted to experimental work on the application of radioactive tracer techniques to metallurgical problems. The immediate programme includes the development of more sensitive techniques for measuring the activity of very small amounts of active material; the identification and distribution of a particular constituent in a metal as, for example, in investigations involving grain boundary concentration of an impurity; studies of diffusion in metals and the analysis of activated samples for the determination of extremely small impurity levels in metals. The plan underlying the design and equipment of the section has been to provide facilities for carrying out on metals, of all but the highest radioactivity most of the operations normally applied to metals in a research laboratory.

The main feature of the section is a foundry which is equipped with gas-fired and induction melting furnaces, casting equipment, heat-treatment furnaces, a small bar and sheet rolling mill and a suitably protected safe for the storage of active isotopes. Provision has been made to handle active metal in quantities up to 6 lb. Next to the foundry is a combined workshop and laboratory for metallographic preparations and there is also a combined chemical and physical laboratory in which chemical analyses and measurements of activity will be carried out. A room leading from the workshop contains the active extract plant. The whole section is approached through a semi-sealed door and changing rooms.

AIR-CONDITIONING EQUIPMENT

The air-conditioning system in this part of the building is separate from that in the remainder. Air is drawn into a duct by an intake fan in the non-active plant room on the upper floor over the foundry and, after being warmed to 65 deg. F., is passed through ducts to each room as shown in the illustration. It is extracted through another system of ducts by a second fan situated in the active plant room on the ground floor. At points in the extract duct in each room openings are provided to which extensions to hoods over the machines are attached. Before reaching the exhaust fan the air is freed from solid matter. After passing the fan the air is released through a high chimney, at the base of which there is an opening for the continuous monitoring of the activity of the filtered air. The intake and exhaust fans are interconnected so as to produce a slightly negative pressure throughout the section. The possibility of contamination passing to the rest of the building, which is kept at a slightly positive pressure by its own system of air circulation, is thus avoided. A pre-set differential pressure valve extends through the wall above the door leading to the section, one end being in the non-active positive pressure side and the other in the active negative pressure side. If for any reason the pressure in the tracer section should rise above that of the rest of the building alarms will sound. A similar valve connected to the same alarms is placed near the active exhaust fan to deal with any failure in the inter-relationship between this and the intake fan.



A corner of the radioactive-tracer foundry showing the special air-conditioning ducts.

The rooms are designed to be easily washed down, and have floor ducts and sinks down which all active liquid passes through polythene drains to 1,000 gallon delay tanks situated under a small separate pump house. Here it remains until its activity has fallen to a level sufficiently low to allow it to be pumped into the sewers. Separate sinks and drains are provided for non-active liquids, but as such liquid might be inadvertently contaminated with active material it is passed to a separate storage tank from which it can be pumped after its activity has been checked.

The remaining accommodation on the ground floor includes a battery room and sub-station, which serves the Division as a whole. Ducts in the false ceiling of the corridor are used as a main artery for the distribution of the electricity, gas, compressed air and hot and cold water services to both floors.

X-RAY DIFFRACTION STUDIES

The upper floor of the new building is designed for X-ray diffraction studies of metals and for electron microscopy. It consists mainly of a single large room which can be divided by easily removable partitions into a number of cubicles and small laboratories. Each of these cubicles is intended to contain a single piece of equipment and each can be darkened. A system of roof lighting enables each cubicle to receive full daylight no matter how the space is divided. The arrangement ensures that a wide range of equipment is available at any time and preserves sufficient flexibility for new methods to be introduced and older ones discarded, without an interruption of active investigations. Equipment not required by immediate programmes may be readily removed from its cubicle and placed in store, and the space employed in building up the equipment for some other type of work. As a corollary to the use of removable partitions all services in the section are carried in a system of wall and floor ducts. In addition to the standard services already mentioned there are a circulating system of clean distilled water at 50 lb. per square inch pressure and 20 to 25 deg. C. temperature for cooling purposes,

and a "quiet" phase of 230 volt alternating current for apparatus requiring short term mains stability.

The input of the ventilating system for the first floor is shared with the ceramics section below, but whereas extract ducts lead direct from each room in the X-ray section to an exhaust fan on the roof, about 50 per cent. of the air extracted from the ceramics section is recirculated, the remainder being ejected over the roof. As already mentioned, this ventilating system is arranged to give a slight positive pressure in both the sections it serves.

X-RAY SECTION

The present lay-out of the X-ray section consists of a row of six cubicles for X-ray sets opening off a common central working space. At one end of these, two dark rooms and a photographic printing room are situated. The X-ray units in four of the cubicles are primarily intended for standard X-ray techniques, such as powder camera work and orientation studies, but there is space for ancillary equipment to be built round the apparatus for specialised work when necessary. The remaining two cubicles have X-ray sets for Geiger-Müller counter work, and are at present used for high precision measurements of diffraction line intensities and preferred orientation. In the centre of the building and opening on to the common working space, is a cubicle containing an X-ray set for work requiring a fine focus source of radiation. Along the east side there is a preparation room for electron microscopy, opening into a central cubicle housing the microscope, and two laboratories for a soft X-ray spectrograph and a recording microphotometer.

The present superintendent of the Metallurgy Division is Dr. N. P. Allen.

THE LINK BETWEEN OPERATOR AND DESIGNER

INTRODUCING NEW AIR-LINERS INTO SERVICE

The engineering organisation and practices of British European Airways were described in a paper entitled "Practical Experience of Airline Engineering," given before the Royal Aeronautical Society in Chester, on Thursday, April 8, by Mr. R. C. Morgan, chief project and development engineer of the Corporation. We give below extracts from Mr. Morgan's paper, in particular from those sections in which he discusses the problems of introducing new types of aircraft into operation.

The high initial cost of the modern transport aircraft, Mr. Morgan states, means that it has to operate continuously at high annual utilisation for periods approaching ten years, before the initial capital cost can be paid off. During this time all kinds of technical, aerodynamic and engineering problems arise. Furthermore, over such a period, development of the equipment for operational and commercial reasons is bound to be required.

On top, therefore, of daily routine maintenance of the equipment to a continuous acceptable standard, the engineer in the airline has to cover a very wide field, including collecting and interpreting the experience of all parts of the airline (maintenance, flight operations, traffic, schedules planning and so on) and on the equipment in use; solving all the technical problems arising with the equipment; assessing proposals to alter the equipment; and initiating development and techniques for maintenance and operation, and interpreting the whole of this work into requirements for new equipment.

In British European Airways an early decision was made to use British aircraft and while the Viking already ordered for B.E.A. was being prepared for service, work started on a propeller-turbine replacement, the Vickers Viscount (V.C.2) to come into service about 1950-51.

Meanwhile, the prototype Airspeed Ambassador (or Elizabethan as it is now known) had flown. This aircraft was one of the basic Brabazon Committee types on whose design and testing a large sum of public money had been spent. Influences from outside the Corporation caused an order to be placed for twenty Ambassador aircraft.

As a result of this a great deal of B.E.A. engineering effort had to be diverted to this project and B.E.A. has two aircraft types to do the job of one.

One advantage has arisen from this situation, that of being able to compare the performance and efficiency of two different aircraft doing the same task under similar circumstances. It has also enabled experience of the requirements for civil transport design to be built up more rapidly than would otherwise be the case.

The following broad principles emerge :—

1. No airline can afford to use two different aircraft types when one can be made to do. The costs of duplicating aircraft types within a particular airline are so high that whenever possible the same basic type should be used for different roles (e.g., passengers or freight) and for routes of different characteristics.

2. Success in designing new transport aircraft lies in the engineering of every detail from project to production line, and in the degree to which the requirements of day-to-day transport operation are understood and incorporated in the design. This demands continuity of experience over a long period of time and a close operator/manufacturer liaison.

3. Civil and military requirements are so dissimilar (in some fields the divergence between the two is even increasing) that the development of civil transport aircraft from military designs is not generally likely to produce the best civil aircraft.

4. The costs of introducing new equipment into service must be assessed realistically by the first user and offset against the advantages offered by the equipment. The cost of the development in service which must be done by the first operator is considerable.

For a given total flying-hour programme, the direct labour force required will have to be higher if two types are used instead of one, but even more serious increases in cost occur on indirect labour and as a result of operational and scheduling difficulties. Practically every technical problem arises twice, but in a different way, so that the development work is duplicated and twice as many modifications are required to produce the same number of flying hours.

Generally speaking, new equipment seems to perform well when it is first put into service and then frequently falls into a trough of difficulty. As the flying hours start to pile up on the equipment, and as economic stringency dictates its operation under normal conditions with strict economy in the manpower looking after it, then difficulties begin to assume more serious proportions.

Not until the operator has taken delivery of his full fleet of aircraft and not until his operating utilisation is well up and his continuous maintenance routines are in full swing with limited component floats, can he afford to relax. This process may take three years or so, by which time there is probably something else new in the offing.

Close liaison over a very long period between operator and manufacturer is clearly the best way of getting the operator's experience into the manufacturer's and designer's hands.

In times of economic stringency, such as the present, when the need to develop equipment in service for economic operation is paramount, the operator may not have adequate manpower to maintain this liaison to the required degree.

This gap between operator and manufacturer could be further bridged by better training of design staffs in the practical requirements of civil operation, in two ways. Firstly, anyone undergoing engineering training for civil aircraft design, manufacture or operation, should spend a period working for the operator with the development staff. Secondly, selected people should be sent from the drawing office and technical departments of the civil aircraft manufacturer to the operator for a period of two years.

For ease of maintenance and operation, the detail designer should bear in mind the following points: simplicity, reliability, accessibility, replaceability (not synonymous with accessibility), interchangeability, repeatability of performance, robustness, fool-proof en-route serviceability without special tools, and a control cabin that does not trap dirt and foreign bodies. He must also be fully aware of what will have to come off the aircraft, and when, in the maintenance cycle. Interchangeability, to the operator, means that a component can be taken off one aircraft and put straight on to another, with no drilling, reaming or filing.

To establish the basic procedures for maintenance of each part of the aircraft, and to check on the suitability of detail design and component accessibility, B.E.A. instituted a series of checks to be made on the prototype aircraft and, where this was not representative, on the production line at various assembly stages.

By witnessing the trials and discussing the results, the manufacturers' design staffs have found they can get first-hand experience on their own designs cheaply and with a minimum waste of time.

The report sheet for each servicing trial includes the name of individuals witnessing the trial and description (e.g., remove and replace nose-wheel assembly or pressure door seal or freight door sill, and so on), the time for removal and replacement, number of men required, tools used, and so on. Against each part of the operation is recorded any difficulty encountered, suggestions for re-design if necessary and, also, special tools or techniques required.

The record sheets are first used for design discussion, to provide the basis for the maintenance schedules, information for planning and/or ordering tools, and so on, and then are kept as part of the basic development data against the time when trouble arises.

We have a very small number of engineers in the United Kingdom who are in a position to transmit operating experience to the manufacturer. We must therefore concentrate the maximum effort on the smallest possible number of new types. Only by so doing can we produce aircraft which will succeed in our own airlines and in the export markets.

INSTITUTION OF NAVAL ARCHITECTS

H.M. YACHT "BRITANNIA"

Continued from page 486

In last week's issue, we reported the annual general meeting of the Institution of Naval Architects, held in London on the morning of Wednesday, April 7, and followed this with a summary of the first paper of the Spring Meeting, which was presented by Sir Victor Shepheard, K.C.B., Director of Naval Construction, Admiralty, and described "Her Majesty's Yacht Britannia."

In presenting the paper, Sir Victor drew attention to two errors in the advance proof, pointing out that the two diagrams on the right-hand side of Fig. 7 should be interchanged with the two corresponding diagrams on the right-hand side of Fig. 8; and that in Fig. 7, the caption under the first column should read "ahead seas" (not "following seas") and that under the second column should be "following seas" (not "ahead seas").

The discussion was opened by Sir James M. McNeill, who said that, as representative of the builders, he wished to re-emphasise that the ship had been designed to the minimum dimensions. There was one test of a design, "Did it look well when it was finished?" The Britannia looked smaller than she really was, and that was a good guide. In the section of the paper headed "Hull Form," mention was made of the model experiments and the adoption of the semi-bulbous bow. There were good reasons for proposing that; it gave excellent access to the structure and allowed of sound workmanship in a very awkward part of the ship; and the forms of the sections, as shown by the diagrams, all combined to avoid the fault of pounding in head seas. The benefit derived from the adoption of the semi-bulbous bow was about 5 per cent. in power at 22 knots, but that advantage disappeared at about 18 knots.

LIFE-SAVING RAFTS

They had gone back to merchant practice by the adoption of sprinklers and the positioning of oil-fuel and water systems, and also in the arrangement of the sewage tanks. Rafts had been adopted for some of the life-saving appliances. The capacity provided was very ample, and he thought there was a case for the adoption of such rafts in merchant practice; they might usefully be applied to all passenger ships, particularly those carrying large numbers. The early trials, held during the first half of November, enabled them to deal adequately with local vibration that arose. Happily, it was extremely small; the addition of local stiffening was done in the most economical way, and the final results justified the procedure. As Sir Victor had indicated, all the technical conditions had been fully met, and the ship's performance and the builders' trials justified all expectations, which was a good guarantee of the vessel's behaviour on service. The excellence of the design reflected great credit on Sir Victor and the Admiralty staff.

Surgeon-Commander J. Lees, R.N., thought that it was not generally realised by the general public that there were two different types of hospital ship. There was the military hospital ship, designed to transport the sick and wounded back to the base for hospital treatment, and there was the naval hospital ship, which had to serve as a base hospital with the fleet in place of, or to augment, shore hospital facilities. The Britannia was of the second type. He doubted whether she would be suitable as a military hospital ship, but she was eminently suitable as a naval hospital ship.

The ship would be fully equipped as a hospital, with the specialist departments which were the most important parts of a naval hospital ship. She would carry a surgical specialist, to advise on and treat surgical cases, casualties and ordinary surgical emergencies. She would also carry a medical specialist, to advise on medical cases; even in war time the ordinary medical cases formed the larger percentage of the patients. They were not concerned so much with war casualties as with the treatment of the sick and with providing specialist out-patients' consultations for the fleet. The ship would have a fully-equipped clinical laboratory for the investigation of disease, an X-ray department which would compare favourably with that in any shore base hospital of comparable size, i.e., having 200 beds. The set would be of 200-MA, 100 kV, which was larger than would be found in any hospital ashore. There was also an ophthalmic department, where an eye specialist would be able to treat eye cases and do the complicated ophthalmic operations and investigations which might be necessary.

There had been some criticism of the size of the hospital, with 200 beds, and suggestions that it was too small. For a military hospital ship, perhaps it would be; it would not be economical to take only 200 patients for a long sea voyage back to their base. They were not concerned, however, with taking patients back to their base, but with treating them on board and returning them to their units, fit for duty; the Britannia would be a base hospital. There were many shore hospitals with 200 beds and less. There was a very definite place for a ship of that kind.

The sun deck aft had been strengthened to take a helicopter. That was primarily a hospital requirement; the helicopter was a most useful form of transport for getting patients to and from a hospital ship, and the strengthened shelter deck was primarily there for the use of the hospital. No doubt, it would be very useful to the Royal Yacht, too. On occasions, the ship might have to perform the function of a military hospital ship. Although it was not the intention for her to be used primarily as a hospital carrier, she could help by evacuating a reasonable number of casualties.

Dr. R. W. L. Gawn said that his acquaintance with the Britannia had been limited to the models and, later, to the trials. Sir Victor had referred, *inter alia*, to the wide scope of the tests which now went to improve the design of ships. Formerly the traditional tests were concerned with resistance and propulsion in calm water; but here there were also tests of seaworthiness, cavitation, vibration, air flow, etc. The photographs of the cavitation of the propeller, reproduced in the paper, were taken with a very fast flash—25 microseconds. It was just possible to detect, on the face of each blade near the leading edge, and from about half to three-quarter radius, a wisp of sheet cavitation. When they examined the propellers in dock after the trials, it was found that there was slight pitting at that point; it was the only part of the blades that was affected.

SINGING PROPELLER

Sir Victor mentioned that one of the propellers was found to "sing." The ship was due to dock at an early date and something had to be done at short notice. They had had some experience of singing propellers previously, and from it they knew that, if the edges were machined to rather a fine thickness, the trouble would probably be cured. The Director of Naval Construction wisely insisted that the thinning should not be carried too far. They measured the frequencies and the volume of the noise, and also tried to estimate the eddying vorticity at the trailing edge. The figures agreed fairly well, and so they decided to grade the finish of the edge, to avoid any excitation of frequencies giving resonance round the periphery of the blade. They had not quite achieved success, but the improvement was marked and they looked forward to an opportunity to test the further modification. The paper contained a wide range of information on ship motion which, he suggested, had a few general lessons. The amplitude for a shallow wave showed a ratio that was greater than the amplitude in the steeper wave. That was consistent with the results usually obtained from such tests on models of other ships, and it pointed to some limitation of the linear theory and to the scope for further investigation.

Another matter of interest was the peak amplitude. It was never much greater than about 20 per cent. in excess of that of the surface wave, for pitch, and that sort of amplitude ratio and magnification factor was obtained in tests generally. On the other hand, in the rolling diagrams the ratio was more like 5 : 10, which immediately suggested that the damping was extraordinarily heavy in pitch; but there was still plenty of scope for increase of damping and for bringing those peak amplitudes down. At 10 knots the hull resistance was roughly proportional to the wave height, though not exactly so; the peak occurred in a wave about 350 ft. long. The motion of the wave was considerably less than the peak motion. That occurred in a wave more like 500 ft. long, and suggested that the phase of the motion was playing an important part; that was also a matter for further investigation. With that diagram, the resistance at uniform speed in waves was measured; but there was considerable fluctuation, and the curves represented the broad average of the resistance over the length of run in the experiment tank.

DESIGN OF HOSPITAL SHIP

Commander (E) E. G. Allen, representing the Engineer-in-Chief, Royal Navy, emphasised the difference between the design of a hospital ship and of a Channel steamer. In the case of a hospital ship, steam must be kept up in harbour for quite considerable periods, for there were heavy loads for air-conditioning the wards, the electrical load, etc.; therefore the boilers could not be entirely shut down. In keeping steam, they must not upset maintenance. Consequently, the machinery and the pipe installations must be so designed that a proportion of the machinery could be refitted while the remainder was in use. That meant that the pipe system must be carefully thought out, and the necessary valves put in for isolation purposes. In the Britannia they had managed to do that with very little extra equipment; in fact, it had been done purely by re-arranging the pipe system. From the engineering point of view, they had a very good set of machinery in the ship. She certainly did her trials very well.

Mr. K. C. Barnaby referred to the author's statement that the "predicted two-node frequency was 116 cycles per minute." A somewhat higher frequency might have been expected from the dimensions of the yacht. It would be interesting to know if the prediction was confirmed in practice and with the ship in deep water. It was stated that a semi-bulbous bow was adopted on the suggestion of the builders. While, no doubt, that feature had contributed to the high performance of the vessel, bulbous bows had the reputation of producing wetter foredecks. It was to be hoped that there had been no loss of amenity on that account. The severe modern profile of the Britannia would no doubt evoke criticism from those who preferred the traditional style. They would recall the Nahlin, also a Clydebank ship, and perhaps the most graceful power yacht ever built. Such a comparison would be grossly unfair, however. The new ship would have a yacht tonnage of presumably about 5,200 tons. On that basis she had to provide for about double the complement per 100 tons and, in addition, a large number of special rooms. It could be argued, also, that a Royal Yacht should not look too beautiful; it might crowd more wrong ideas about extravagance into irresponsible heads. Examination of the plans would show, on the other hand, that the Admiralty had succeeded not merely in the familiar job of cramming a quart into a pint pot, but in cramming two entirely different quarts into the same measure.

Mr. R. Leslie Champness described the paper as a most impressive record of the care and

thought and scientific solution of all points arising in the design of the vessel. As such, it epitomised the wide activities and many facets and skills of the Royal Corps of Naval Constructors, the builders and the engineers. He wished to raise one other point. It was to say how far from British public opinion and generosity were some of the questions recently heard about the Royal Yacht in "another place." He had not the slightest doubt that there were several millions of citizens in the country who, as part of the greatest maritime nation in the world and at the start of a new Elizabethan era, would gladly have considered the gift (apart from public funds) to their Sovereign of a dream yacht as an appreciation of the incalculable value to the nation and to the Commonwealth of Her Majesty's present world tour. He wondered what might have happened if the Royal Yacht had not been conceived in 1939, or in 1951, in periods of great stress, and whether British yacht designers would have produced exactly the same ship in other circumstances.

Mr. H. S. Pengelly said that in the section headed "Rudder" it was stated that "The centre of pressure was abaft the rudder axis at all forward speeds and for all rudder angles tested. It was not possible, however, to bring the centre of pressure farther forward without unacceptable modification to the stern form." Personally, he was glad that it was not possible to bring the centre of pressure forward. It was a good thing for a rudder to be slightly underbalanced; then, if anything went wrong with the steering gear, the rudder tended to come back to 0 deg. and not to swing round to the full rudder angle. He had had experience of that in an aircraft carrier in the past year. He would like the author to add, if possible, the actual torques on trials when the ship was proceeding ahead at 22 knots and astern at 14 knots.

Dr. J. F. Allan said that the paper gave a good idea of the wide range of points that had to be studied before final satisfactory arrangements could be made. Most of those considerations were included in the design of modern merchant ships; it was something which had grown up over the last 20 or 30 years. In particular, the interest displayed in the design of superstructures and funnels to improve air flow in merchant ships, and especially in large passenger liners, was very great, and had become a major activity in one of the wind tunnels at the National Physical Laboratory. The experiments illustrated in the paper were most interesting, but the solution found, while effective in certain areas, appeared to create more violent concentrated jets of air in other areas. That might be unavoidable; as had been pointed out in the paper, that bridge deck was forced on the designers. He wondered if it was possible to obtain a different solution to the problem; for example, by putting a horizontal plate at a suitable height on the base of the structure at the back of the steps of the deck, to intercept the down draught and deflect it sideways and forward. Concerning the rough-water experiments on seaworthiness, a study of the diagrams indicated that the maximum increase of resistance was at the point where the amplitude of heave and pitch was only about half, or less than half, of the maximum of the heave and pitch. That seemed rather difficult to explain.

Mr. G. de Rooij asked which parts of the ship were electrically welded and the number of items electrically welded.

ELIMINATING VIBRATIONS

Sir Victor Shepheard, replying to the discussion, said that Sir James McNeill's point that the semi-bulbous bow was a good thing from the points of view of building and of maintenance was an important one. It had been remarked that a ship such as the Britannia had to last for 50 years; it would not do so unless there was good maintenance, and they had to make sure that they could get round the structure, to coat it and de-rust it. Sir James also observed that the early trials were made particularly to see if there were faults in the ship which could be put right before she was taken over. Fortunately, there were not many. A little stiffening was added to reduce vibration; it was not very much. Surgeon-Commander Lees had said that a helicopter was a necessity for a hospital ship. A trial was carried out on April 5 with a helicopter, and no doubt a helicopter would be used while she was on tour in the Mediterranean. Surgeon-Commander Lees, Sir Victor added, was the officer concerned with the hospital requirements.

With regard to the thinning of the propeller edges, the fact that they did not go so far as Dr. Gawn would have liked was probably the reason why they did not eliminate the singing altogether; but the singing now occurred only at very low speed, and he was sure it would not affect the ship on passage. He would add particulars of the actual frequencies of the singing, in the final edition of the paper, if desired. He agreed that there was great scope for further investigation on pitch and heave, and Dr. Gawn was the man to do it. Perhaps at some time Dr. Gawn would give a paper on the work he had started on pitch and heave.

Mr. Barnaby had asked whether the predicted two-node frequency of 116 cycles per minute was confirmed on the trials. The results of the experiments were generally confirmed; he could include some figures in a written reply. As to Mr. Barnaby's fear that the semi-bulbous bow will make for a wetter foredeck, that was not so. Many experiments were made in the tank on seaworthiness and only once during the trials was water taken over the forecastle; that was due largely, of course, to the good freeboard. From experience over several months, he thought she would be a very dry ship.

WELDING OR RIVETING

In regard to the rudder, I agree entirely with Mr. Pengelly concerning the position of the centre of pressure. They could have brought the centre of pressure a little farther forward without having over-balance, but they did not want to do it without altering the shape of the stern. He did not think it would make much difference. Particulars of the torques on the trials would be added in the written reply.

As Dr. Allan has said with regard to air flow, the arrangements at the fore end of the vessel were such that back draught was unavoidable. There had to be a Royal bridge, and undoubtedly it improved the appearance of the ship. Dr. Allan suggested that they might have tried horizontal plates. There was the question of the view from the windows on each storey, and such plates would have affected the appearance of the ship. The arrangement fitted was quite satisfactory. Dr. Allan also remarked on the relation between pitch and heave, and the increase of resistance. There was need for a great deal more research on that point; it is one of the things on the future programme.

In reply to Mr. de Rooij: the paper did state that the shell plating above the light waterline was worked flush; and that, below the waterline, the plating was lapped, the plate edges forward being faired with composition. Butts of shell plating below the waterline, and the shell plating in way of reserve feed tanks and fresh-water tanks were welded. The internal boundaries of oil fuel tanks also were welded. The ship generally was riveted, but not because there were any doubts about welding; it was done in consultation with the builders, because they thought they would get a ship of better appearance when riveted than when welded. The outside of the hull above the waterline was painted with a high-gloss paint, and the effect of a high-gloss paint on a welded surface was not good. It is difficult to get a perfectly faired surface with welding, but with riveting a good surface could be assured.

The President, in thanking the author for his paper, said that Sir Victor had quoted, at the beginning of the paper, the words used by Her Majesty, that "a yacht is a necessity and not a luxury for the Head of our great British Commonwealth." He thought they could all take that to heart, and could feel that that requirement had been most satisfactorily met.

The meeting was then adjourned until the following morning.

ANNUAL DINNER

In the evening of April 7, the annual dinner of the Institution was held at the Connaught Rooms, London, W.C.2, the chair being taken by the President. The attendance, nearly 1,000, is understood to be the largest in the history of the Institution. The guests included: Their Excellencies the Danish, Greek, Italian, Norwegian and Portuguese Ambassadors, the High Commissioners for Australia and Ceylon, and the Rt. Hon. A. T. Lennox-Boyd, M.P., Minister of Transport and Civil Aviation, who proposed the toast of "The Institution."

Ten years before the Institution was founded, said Mr. Lennox-Boyd, there was established the Mercantile Marine Board, which subsequently became the Marine Department of the Board of Trade and eventually a department of the Ministry of Transport. In 1854 the Merchant Shipping Act was passed. It had 528 clauses, and passed its second reading in four hours. The 1953 Transport Act took 134½ hours; if it had been dealt with at the same rate as the 1854 Act, it would have been passed in 16 minutes. The Institution, the Minister continued, had had a vigorous and very useful life. It had proposed a system of watertight sub-division as long ago as 1867, and had had much to do with the alteration of the tonnage laws by the Act which received the Royal Assent on March 9, 1954. He hoped that they would be able to report definite progress during the present year in the prevention of oil pollution.

Lord Runciman, who responded to the toast, said that they must all feel pride in the provision at long last of a Royal Yacht. No vessel could be too good, or too expensive, for the Queen and the Duke of Edinburgh to travel in. If there were any who thought otherwise, he could only describe them in terms more seamanlike than Parliamentary. There were signs that the world's seaborne trade was not likely to increase in the near future, and the trend of events indicated that the competitive position of British shipbuilding, if not actually in jeopardy, was at least in question. The costs of ships were largely outside the direct control of the shipbuilders. Probably there never was a time when there was a greater need for research than at present. Engines were in existence which weighed only 6 lb. per horse-power developed, which posed problems for those who were accustomed to designing on a basis of 180 lb. per horse-power.

The toast of "The Guests" was proposed by Sir Harold Yarrow, Bt., who observed that the great-grandfather of the present Greek Ambassador had designed the first Greek warship built in a British shipyard. His Excellency the High Commissioner for the Commonwealth of Australia (the Hon. Sir Thomas White, K.B.E.), who responded, spoke of the immense benefit to the Commonwealth of the Royal tour, and welcomed the action of the Institution in establishing a Branch in Australia.

To be continued

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INSTITUTION OF NAVAL ARCHITECTS SCHOLARSHIP

Research on Application of Light Alloys to Shipbuilding

A research scholarship of the value of £400 per annum and tenable for two years is being offered by the Aluminium Development Association to encourage and facilitate research in the application of light alloys to ship construction. The scholarship will be administered by a committee of the Institution of Naval Architects, and it is hoped to make an award in September of this year. Full particulars of entry, which closes on June 30, can be obtained from the secretary of the Institution, 10 Upper Belgrave-street, London, S.W.1.

ELECTRICAL DEVELOPMENT CONFERENCE

SERVING THE CONSUMER

A conference, organised by the British Electrical Development Association, was held in London from Tuesday, April 6 to Friday, April 9. Its object was to provide the sales staffs of the Electricity Boards with information which would enable them to advocate the greater use of electricity, and to discuss the related sales management problems.

At the first meeting on Tuesday morning, April 6, which took place in Caxton Hall, Westminster, Dame Caroline Haslett, chairman of the Electrical Development Association Council, presided. She said that this was a great year of opportunity for the electricity-supply industry. It had now emerged from the dark tunnel of frustration into the sunshine of opportunity. That opportunity might be illustrated by saying that not only did the public need electricity more than ever, but the industry must discover methods of improving the load factor.

IMPROVING THE LOAD FACTOR

In declaring the Conference open Sir Henry Self struck the same note. The Government having given permission to go forward, the industry was about to launch an advertising campaign of considerable size. This, it was hoped would improve the load factor, which was falling and in some areas was as low as 41 per cent. As new plant came into operation this position must be improved, in order that the advantages of higher thermal efficiency could be passed on to the consumer in the form of lower prices. As regards the future, the problems of recruiting and training sales staff must be dealt with and rural electrification must be encouraged. As such electrification could not be expected to pay its way for several years it was necessary that its cost should be explained and the reasons for the development given.

SALES ORGANISATION

A paper on "The Organisation of Sales and Service to the Consumer" was then presented by Mr. J. Gogan who remarked that the future prosperity of the industry would depend on sagacious planning and the special brand of hard work that only unflagging enthusiasm could engender. Service centres would not work effectively unless the staff were able and willing to impart information convincingly and with friendliness. To produce these qualities, competition between the centres themselves was useful.

One trouble was the enforced neglect of the industrial consumer. To overcome this he suggested the establishment of industrial showrooms, where special exhibitions and demonstrations could be staged for selected individuals. A quarterly bulletin on electrical industrial matters would also be useful.

Newcomers to the staff should be at once taken in hand by their immediate superiors and by group training classes. A later need for specialist training might be met by the Electrical Development Association. The question of incentives for the sales staff must be tackled at once if some of the best people were not to be lost. To foster enthusiasm it should be made easy for assistants to instal the latest equipment in their homes, so that they might learn its merits at first hand.

The present downward trend in domestic electricity consumption must be taken as a challenge to restore public confidence and to create an atmosphere favourable to selling.

COMMERCIAL CONSIDERATIONS

At the meeting on Tuesday afternoon the subject of "Selling Electricity: Some Commercial Considerations" was dealt with by Mr. R. E. Gamlen. It was essential, he pointed out, that those who generated and distributed electricity should be able to exert some influence over the sale of equipment which was connected to the mains. In towns, the consumer was entitled to demand a complete service, at any rate as far as the supply of electricity and the provision, repair and maintenance of the major current-carrying apparatus were concerned.

Area Boards must pay close attention to the cost of selling electricity. The gross surplus was being restricted to a comparatively low level owing to the profits being limited by discounts and the lack of freedom to dispose of stocks imposed by the fair trading policy. Selling must be improved by a better "load factor," so that assistants were always present when prospective consumers were a maximum.

STAFF TRAINING PROBLEMS

The morning meeting on Wednesday, April 7, was devoted to the consideration of a paper on "Training Commercial Staff," which was presented by Dr. A. G. Beverstock. He suggested a scheme of commercial engineering apprenticeships for which the electricity-supply industry was particularly suitable. Such a scheme had been set up experimentally by the Southern Electricity Board with the object of providing training which would lead to such positions in the Commercial Department as sales and service representatives, development engineers, showroom assistants and specialised posts in agriculture and refrigeration. These apprenticeships would last five years, during the first three of which the syllabus would follow the lines for an electrician preparing for the City and Guilds Interim Electrician's certificate or the Ordinary National Certificate. A course at a technical college leading to a certificate in commercial electrical engineering and to either the Higher National Certificate in electrical engineering or to the examinations of the Incorporated Sales Managers' Association would follow. Instructions would be given on the structure of the industry in general, on the power industry with special reference to the Board's area and on elementary law, statistical methods, business organisation and salesmanship.

Details of a scheme of progressive staff training, which had been established by the Board to help the senior staff to be kept familiar with the problems met by those in the field, were also given.

ELECTRIC FLOOR WARMING

"Electrical Floor Warming" was the subject of a paper presented by Mr. J. W. Moule at the meeting on Wednesday afternoon. This dealt with the subject more from the point of view of the commercial than the specialist engineering staff. Experiments on comfort and heating suggested that warmth should be transmitted to the human body mainly by radiation from uniformly warm surroundings and that air movements should be minimised. The usual convection systems fell far short of these criteria. On the other hand, floor heating warmed the occupants of a building mainly by radiant heat, convection air currents being considerably reduced.

Designing a floor-warming installation was initially a matter of calculating the heat losses that would occur. The floor temperature should not exceed 75 deg. F., to prevent discomfort. In order to provide sufficient heat to meet this condition in cold weather the whole of the floor surface must be raised to that temperature. In the Panelec system this was secured by running the heating wires in conduit, which was covered with wire netting before the top screed was laid. This netting was thus raised to a uniform temperature, so that the transmission of heat through the floor was also uniform. The heating cables consisted of two cupro-nickel resistance conductors insulated with asbestos and enclosed in a lead sheath. The loading was 10 watts per foot run. Pyrotenax cable had also been used.

Floor heating, said Mr. Moule, was cheap to install and the Panelec system would initially cost only two-thirds of an ordinary central-heating system. It was an off-peak load and an interesting future development might be ripple control. On the selling side there was need for specialised engineering heating knowledge and for familiarity with the problems of the heating engineer. There must be an after-sales service, particularly to check the thermostats and thus to prevent increased electricity consumption. The initial consumption would be relatively high, owing to drying out the building and heating the earth beneath it.

ELECTRICITY FOR PRODUCTIVITY

In a paper on "Electricity for Productivity, Selling the Idea to the Industrialist," which was presented on Thursday morning, April 8, Mr. J. R. Anderson suggested some ways of bringing the productive advantages of electricity to the knowledge of the consumer and of interesting them in modern techniques in their own works. It was necessary to establish personal contacts through a highly trained specialised staff. Contacts could be made by canvassing, correspondence, exhibitions and advertising. The staff should be divided into two categories, one of which should be trained to handle general industrial inquiries and the other should be capable of advising consumers on a specific application and of preparing schemes which might of necessity be extensive and elaborate.

Typical of such staff would be specialists in mechanical handling, welding, high-frequency heating, electronics, machine tools, ceramics and lighting. These subjects suggested a possible method of training industrial sales engineers. It would be necessary for the specialist staff to be in close touch with the manufacturers and to be backed up by first-class technical services. These would include library facilities, as it would be found invaluable and in the interests of the consumer to go to considerable trouble to obtain technical information and present it in a sufficiently non-technical form for the consumer to digest. By attending meetings of the electrical institutions and taking part in the discussions they should make opportunities for meeting the staffs of industrial consumers.

THE SCOPE FOR ELECTRONICS

At the final meeting on Thursday afternoon, April 8, Mr. W. P. Warren presented a paper on "The Scope for Electronics in Industry." Development in this field had, he said, generally been slow, owing to the lack of appreciation in many industries of the need for professionally-trained engineers to fill positions covering the whole field of production. The supply industry

should therefore endeavour to provide a service which was at present lacking and to stimulate utilisation by demonstrations of the new techniques. To secure the adoption of these techniques detailed examinations of the complete production processes were necessary. Electronic applications were no exception to this rule, since an examination of the whole flow line often revealed weaknesses in either materials handling or materials processing.

The main applications of electronics in materials handling were the control of conveyors and hopper feeds and levels; very high-frequency communication between a central control point and long-distance trucks; television; and tension and loop control in strip and cable manufacture. For actual processing the main fields were high-frequency induction heating, very-high-frequency dielectric heating and electrostatic applications. The electronic control of resistance, spot, projection and seam-welding machines was gaining in popularity and there were many examples of the quality control of a product such as the "capacity" metal impurity detector in foodstuffs. Perhaps the most virgin field of electronic application was that of product inspection, where its adoption would greatly accelerate the work.

The use of cathode-ray tubes for the non-destructive determination of variations in the metallurgical properties of metal parts was comparatively rare, although X-rays were employed in similar applications. Photo-electric cells could be utilised for colour sorting, the rejection of dirty bottles and to ensure the proper labelling of cases, and many types of measurement could be performed electronically more accurately, more sensitively and more speedily than by other methods.

The advantages to be gained by the use of such methods were self-evident, both technically and economically, but it was opportune to emphasise that common sense must prevail to ensure that the applications would result in increased efficiency.

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BULLETIN OF INDUSTRIAL GASES

The British Oxygen Co. Ltd., Bridgewater House, Cleveland-row, St. James's, London, S.W.1, have sent us a copy of a new quarterly technical bulletin which they are issuing. The name of the bulletin is *Torch* and its aim is to keep users of industrial gases informed with regard to new processes and new applications. It is issued *gratis* and is available to operators and managers in engineering.

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AN ELECTRICAL TEN-YEAR INDEX

The *Ten Year Index* which has just been published by the Institution of Electrical Engineers contains 17,000 references to papers which have appeared during the period 1942-51 in Part I (General), Part II (Power Engineering), Part III (Radio and Communication Engineering), and Part IV (Monographs) of the *Proceedings*. In addition, it contains references to Parts IA, IIA and IIIA, in which papers presented at various important conventions were published.

Like the annual indexes to the various parts of the *Proceedings*, which form its basis, this index has an entry for each author in a group of joint authors, for every speaker in a discussion and for every keyword in the title of a paper. In addition, titles of papers are collected under 40 broad subject headings, thus forming small bibliographies on all topics.

The publication can be obtained from the Secretary, Savoy-place, Victoria-embankment, London, W.C.2, at £1 5*s*. to non-members and £1 to members, in both cases post free.

RECORDING ECHOMETER FOR FISHING VESSELS

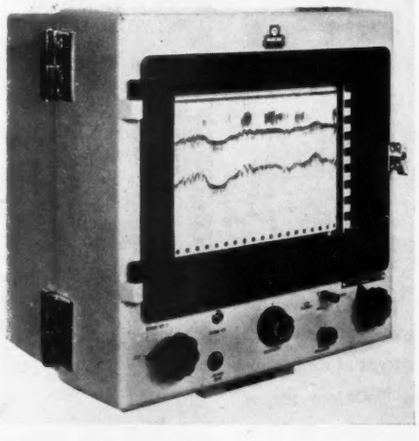
SPARK DISCHARGE ON DRY SENSITISED PAPER

A new recording echometer which, like other instruments of its class, is intended primarily to aid navigation by indicating and recording the depth of water in which the vessel is proceeding, has been designed also to give a clear indication of a shoal of fish should such be present beneath the vessel. Known as the "Graphette," the instrument is now in production by the Marconi International Marine Communication Company, Limited, Marconi House, Chelmsford, Essex.

The complete apparatus, with the exception of the projector, is contained in a single cast-alloy case designed for bulkhead mounting and shown in the accompanying illustration. The projector, by which the ultrasonic waves employed for sounding are produced, is of the magneto-striction type using nickel laminations. It is contained in a heavy casting located above a circular hole cut in the ship's shell plating near the keel. The waves are transmitted downwards in a vertical beam to the sea bed and are reflected upwards to a receiver in the hull similar in principle to the projector and are thereby converted into electrical impulses which are applied to the recording apparatus. The interval between the transmission of an impulse and the reception of its echo is, of course, twice the time taken by the wave to travel from the hull to the sea bed.

RECORDING SOUNDINGS

The transmission and reception of the impulses are both recorded on a horizontally-moving chart by a stylus travelling at a constant speed vertically across it. Two continuous lines are thus marked on the chart, the distance between them being proportional to the time taken by the sound wave on its double journey and thus to the depth of the water since the velocity of sound in sea water may be regarded as constant for navigational purposes at 820 fathoms per second. The chart is in fact graduated to read the depth directly in fathoms. The straight line seen in the illustration at the top of the chart, being produced by the transmission of the impulses, represents the position of the bottom of the ship's hull and the irregular line just below the straight line, being produced by the echoes, represents the contour of the sea bed. The distance between the lines thus shows the depth of the water and the marks visible above the sea-bed line clearly indicate the presence of fish shoals. The other irregular line near the centre of the chart in the illustration is caused by sound waves reflected back from the ship's bottom to the sea bed so that they reach the receiver after having made the double journey twice and thus record twice the actual depth of the water. The second line, and sometimes even a third, is disregarded and causes no confusion in practice.



Echometer for fishing vessels arranged to record, on dry sensitised paper, the water depth and the presence of fish shoals.

CHART GRADUATIONS

The chart is graduated with horizontal lines to read directly in single fathoms from 0 to 80, but by turning a knob the scale range can be altered to read from 60 to 140 fathoms. The overlap of 20 fathoms between the two ranges obviates the need for changing the range frequently when the vessel is steaming in depths varying slightly on either side of 80 fathoms, Vertical lines ruled on the chart 2 in. apar. correspond to a steaming time of 5 minutest and the visible part of the chart being 10 in. long corresponds to a steaming time of 25 minutes. The chart paper is supplied in rolls of 100 ft., and as it is used it is wound on to a second roll for storage. The paper is quite dry although the method of marking it is electrical. When a pulse is transmitted from the projector a high-tension current is passed from the travelling stylus, previously mentioned, through the paper which is impregnated with a conducting substance. Thus a slight burn is caused which discolours the paper leaving a distinct mark, and as the same effect is produced when an echo reaches the receiver the vertical distance between the two series of marks on the chart gives a record of the depth of water. We understand that the records are permanent and do not fade.

SUPPLIES AND CONTROLS

The apparatus is designed to operate from a 24-volt battery, the total power consumption being only 35 watts, but a rotary transformer can be supplied for operation from the ship's mains if preferred. In addition to the range switch previously mentioned, controls are provided for sensitivity and scale brilliance. A stand-by position is incorporated in the main switch to enable the apparatus to be kept in readiness for instant use for detecting fish shoals. When first switched on a period of about 30 seconds is required for "warming up" before soundings commence to be recorded, but when switched on from the stand-by position soundings appear on the chart within three seconds. Provision is made for adjustment to suit the draught of the vessel and to enable a vertical line to be drawn across the chart in order to separate one series of soundings from another.

Among the advantages claimed by the makers for this equipment are that no separate calibrated scale is required for measuring the record and that there is no parallax error or other possibility of ocular inaccuracy in reading it. The apparatus can be used without a separate receiver if desired, but the makers state that the best results in fish indication are obtained with a separate "receiving projector" as described above. The Graphette echometer has been installed with satisfactory results on several trawlers and coastal vessels, including the research vessel Sarsia of the Marine Biological Association at Plymouth.

Fig. 1 Investigating the performance of gas-turbine components at Birmingham University. The combustion chamber is on the left, and the blade-traversing gear can be seen on the axial-flow compressor.

THERMODYNAMICS AND GAS DYNAMICS

COURSE FOR GRADUATES FOR INDUSTRY

The danger of specialisation in engineering, as in other fields, is that concentration on only one section of work may exclude many helpful developments in others – techniques which, having been evolved in one sphere, might provide a key to problems arising in another. This was one of the ideas behind the foundation of a Graduate School of Thermodynamics and Related Studies in the Mechanical Engineering Department of the University of Birmingham. Designed for men with honours degrees and at least two years' industrial experience, the course has now been running successfully for two and a half years; and the University authorities have decided that satisfactory completion of it will merit the award of the degree of Master of Science.

The course sets out to give the student a chance to study, in an intensive and organised manner, the latest developments in his own and related fields. No original research will be undertaken, but much of the apparatus used in the laboratory will be such as is currently employed in research projects. Nor is the course intended to replace the Research School of the department, but rather to be an alternative to it, covering a far wider range of topics than would be possible in a particular investigation. The intention is to stimulate the analytic powers of the student; to make him familiar with modern thought and treatment; and to equip him with a comprehensive knowledge of advanced thermodynamics and its ramifications.

A ONE-YEAR COURSE

The course is nominally of one year's duration, of which nine months will be spent in full-time attendance at the University, and three will be devoted to the preparation of critical reports on the laboratory work carried out. Attendance at the University is from October to July and does include a written examination. As already stated, the normal entrance qualification will be an honours degree in mechanical engineering and at least two (though preferably more) years' experience in industry. In special circumstances applications for entrance may be considered from graduates in subjects other than engineering or from non-graduate engineers with suitable alternative qualifications. In the latter case, the award would be the Diploma of Graduate Studies and the course would take two years. Where the fees are not sponsored by the employer, application may be made for remission, and a maintenance allowance would be considered in special cases. The number of those attending the course is limited so that much individual tuition can be given.

The two main subjects in the syllabus are Thermodynamics and Gas Dynamics and there are five subsidiary subjects. The latter are Dynamics of Machines, Elasticity of Materials, Instrumentation, Mathematics, and Oil Engine Practice. The two main subjects are complementary to each other and the general aim in them is to give a thorough knowledge of the basic principles and a quantitative understanding of idealised cases. In the dynamics of machines, special attention is paid to vibrations and the dangers of resonance, and instrumentation includes a section on electronics designed to give confidence in the use of electrical instruments. Details of design will not be included but the student will be encouraged to assess the values of factors involved in each case.

WORK ON VIBRATIONS

The laboratories have been equipped with a wide range of modern apparatus and on the occasion of a Press visit on April 8, twelve experiments were arranged to show the scope. The vibrations table, which incorporates features suggested by Rolls-Royce, Limited, was fitted up to show the excitation of the various modes of vibration of a compressor blade. The plotting of the nodal patterns was done with sand or lycopodium powder and the measurement of amplitudes by an electric pick-up with an amplifier and oscillope. This set-up is shown in Fig. 2. Excitation of the blade was by a de Havilland motor and amplifier. Torsional vibrations were demonstrated by a two-stroke petrol engine driving a long torsionally-flexible shaft on which were mounted moveable flywheels and a rope brake. Varying the position of the flywheels enabled the different modes to be obtained. At present the speed range is limited between 800 and 2,000 r.p.m., but this is to be extended. Other extensions of scope will be to include the fitting of dampers, strain gauges and means of obtaining cyclic exciting torques. A Cambridge Vibrograph is used to record the vibrations. Other demonstrations with vibrations were being carried out on an *encastre* beam with damping cantilevers at the midpoint, and on a four-stroke motor-cycle engine and gearbox.

GAS-TURBINE OPERATION

The gas-turbine unit that has been installed is intended for an examination of the basic phenomena of the separate components rather than for the consideration of it as a power-producing plant. The layout of the equipment is shown in Fig. 1. There is a three-stage low pressure-ratio axial-flow compressor driven by a 130-h.p. direct-current motor which is arranged as a

Fig. 2 The vibration patterns of a compressor blade are plotted with sand on the blade itself. A de Havilland exciting motor is used.

swinging-field dynamometer. Blade angles may be adjusted, and traverse gear between the fixed and moving blade rows in the final stage enables an examination of the air flow to be made. An alternative blade and rotor system, now being designed, will enable the machine to be used as a cold-air turbine with a Keith Blackman blower supplying the air. Atmospheric pressure combustion experiments are carried out on a Lucas combustion chamber. It is intended to install a small-scale closed-circuit wind tunnel in the near future. The greater part of the axial-flow compressor was designed and made in the Department.

Experiments on pressure waves in exhaust pipes were also shown, using a low-speed oil engine and an opposed-piston two-stroke compression-ignition engine. With the latter, the possibilities of scavenging by utilising the pressure wave were being investigated. Complementary work on induction ramming was being done on a high-speed air compressor. This machine was originally an air-cooled V-twin but has been modified to a single-cylinder water-cooled unit. Indicator diagrams are recorded with a rotary indicator driven at crankshaft speed through an adjustable epicyclic phasing gear. Other work on pressure waves is being carried out in a single-pulse apparatus. In this, a cellophane membrane is shattered by a solenoid-operated needle, releasing compressed air into a pipe-system. An optical indicator and a drum camera record the passing and form of the resulting pressure wave. Measurements can be made at any point along the pipe so that a complete picture of the wave travel can be obtained. Work on this apparatus was the subject of a paper presented to the Institution of Mechanical Engineers in 1948.*

Among the other apparatus on view was a knock-rating engine complete with "bouncing-pin" equipment, and a National engine capable of operating on gas with spark ignition, or on oil with compression ignition, or as a dual-fuel engine using gas and oil.

* "Wave action following the sudden release of compressed gas from a cylinder," by F. K. Bannister and G. F. Mucklow, *Proc. I.Mech.E.*, vol. 159, page 269 (1948).

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ENGINEERING COLLEGE AT OXFORD

On Monday, April 5, the Rt. Hon. the Viscount Nuffield, G.B.E., laid the foundation stone of the new buildings for the City of Oxford College of Technology, Art and Commerce. At present, the work of the college is carried on in congested buildings dispersed throughout the city; some of the University laboratories are used for evening courses. The new buildings will ultimately provide working accommodation for about 4,000 students, together with accommodation in the hall, libraries, restaurant, common rooms, etc., for an additional 1,000. It is expected that the college will be capable of serving the needs of up to 12,000 students each year.

The first part of the college buildings now under construction consists mainly of workshops and laboratories for engineering and building courses, with lecture rooms and drawing offices.

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ROYAL AERONAUTICAL SOCIETY GARDEN PARTY

The annual garden party of the Royal Aeronautical Society will be held in a special enclosure at London Airport on Sunday, June 13. The Nash collection of veteran aircraft will be exhibited, on the ground, for the first time since it was purchased by the Society. Tickets are available only to members and their guests.

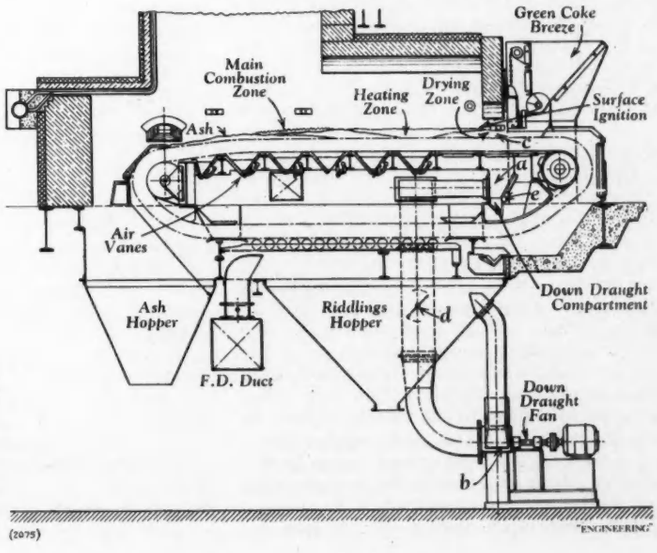
BURNING COKE BREEZE

Combustion Improved by Down Draught

Breeze is the name given to the sizes of coke which range from ⅜ in. down to dust. As a fuel, although cheap, it is of poor quality. If the performance of a boiler using it is to be maintained all the moisture must be removed and ignition must take place before the fuel is introduced into the main combustion zone. One method of effecting this has been to arrange the refractory arches of the furnace chamber so that the hot gases circulating flow over the surface of the fuel bed, thus, in combination with the heat radiated by the refractories themselves, promoting drying and the ignition of the fresh fuel. This is only partly satisfactory, since the penetration of the fuel bed by the hot gases is frequently insufficient to remove the heavier concentrations of moisture. The combustion of breeze with a very high moisture content is therefore uneven and often incomplete.

It is claimed that this disadvantage is overcome in the down draught system, which has been developed by John Thompson Water Tube Boilers, Limited, Wolverhampton; the details of the system are shown on the accompanying drawing. As will be seen, the furnace comprises a down draught compartment *a*, which lies immediately below that part of the grate area on to which the fresh fuel is fed. This compartment is connected by a duct to a fan *b* which is specially designed to minimise the effects of abrasion and induces sufficient down draught to draw hot gases from the furnace chamber through the bed of fresh fuel at *c* into the down draught compartment and through the damper *d*. This bed is thus dried, heated and ignited in a very short time, so that when it reaches the main combustion zone it is in such a condition that the maximum heat is released. As the condition of the fresh fuel may vary from time to time the down draught can be adjusted automatically by the dampers *d* and *e*, so that in the case of stoker-fired boilers the rate of ignition remains constant irrespective of the grate speed.

A definite control is thus maintained over the rate at which the fuel bed is ignited and reaction to sudden changes in load or in the quality of the fuel is instantaneous. Fires, which have been banked for periods up to eight hours can be brought up to full combustion in about ten minutes.



Coke breeze can be burned more efficiently as a result of the down-draught system shown here.

LAUNCHES AND TRIAL TRIPS

M.S. "HØEGH SHIELD."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Skibsaktieselskabet Arcadia, Borre, Norway (Managers: Leif Høegh & Co. A/S, Oslo, Norway). Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, about 18,050 tons on a draught of 30 ft. 5 in.; cargo-tank capacity, about 869,408 cub. ft. Burmeister and Wain nine-cylinder two-stroke single-acting Diesel engine, developing about 9,000 i.h.p. Service speed, 15½ knots. Delivered, March 11.

S.S. "CLAN ROBERTSON."—Single-screw cargo vessel, with accommodation for twelve passengers, built by the Greenock Dockyard Co., Ltd., Greenock, for the Clan Line Steamers, Ltd., London, E.C.3. Main dimensions: 465 ft. between perpendiculars by 65 ft. 6 in. by 39 ft. 7¼ in. to upper deck; deadweight capacity, about 10,000 tons on a mean draught of 27 ft. 3 in.; gross tonnage, 7,775. Reaction steam turbines with double-reduction gearing, to develop 9,400 s.h.p. at 106 r.p.m. in service, constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne; and two oil-fired steam-generating units, constructed by Babcock and Wilcox, Ltd., London, E.C.4. Machinery installed by John G. Kincaid & Co., Ltd., Greenock. Service speed, about 17 knots. Launch, March 17.

M.S. "ANNA."—Single-screw cargo vessel, built by Bartram and Sons, Ltd., Sunderland, for the West African Steamship Co., Monrovia, Liberia. Main dimensions: 445 ft. between perpendiculars by 62 ft. by 40 ft. 2 in. to upper deck; deadweight capacity, 10,830 tons on a draught of 26 ft. 11⅜ in. Wallsend-Doxford four-cylinder opposed-piston single-acting two-stroke oil engine, developing 4,200 b.h.p. at 114 r.p.m. in service, constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 13½ knots. Launch, March 18.

M.S. "AGHIA MARINA."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by William Doxford and Sons, Ltd., Sunderland, for the Porto Blanco Compania Naviera S.A. (Managers: Rethymnis and Kulukundis Ltd.), London, E.C.3. First vessel of an order for three. Main dimensions: 450 ft. between perpendiculars by 62 ft. by 30 ft. 6 in.; deadweight capacity, about 11,000 tons. Doxford four-cylinder opposed-piston oil engine. Service speed, about 13¾ knots. Launch, March 22.

S.S. "SUNBRAYTON."—Single-screw dual-purpose vessel for the transport of bauxite ore to Chaguaramas, Trinidad, and fuel oil to Mackenzie, British Guiana. Built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for Saguenay Terminals, Ltd., Montreal, the steamship-owning subsidiary firm of the Aluminium Company of Canada, Ltd. Main dimensions: 442 ft. overall by 60 ft. 6 in. by 29 ft. 6 in.; deadweight capacity, about 7,850 tons on a draught of 20 ft.; dry-cargo capacity, 311,050 cub. ft. Triple-expansion steam engine developing 1,750 i.h.p. in service, constructed by Rankin and Blackmore, Ltd., Greenock, and installed by the shipbuilders. Steam supplied by two oil-burning Scotch boilers. Speed, 10 knots. Trial trip, March 30.

THE OWEN FALLS HYDRO-ELECTRIC SCHEME

2—TURBINES, ALTERNATORS AND SWITCHGEAR

Concluded from page 500

EACH of the turbines at Owen Falls will be supplied from the headrace and intake dam, the arrangement of which is shown in Fig. 14, through a separate tunnel. An illustration of these intakes and of the power house during construction is given in Fig. 15. The intakes are divided into two sections by a splitter wall about 18 ft. 6 in. long and the water enters them through two mild-steel screens with a span of 14 ft. and a depth of 29 ft. The amount of debris on these screens is indicated by an instrument showing the loss of head. The screens were constructed in five sections, each consisting of a welded plate frame and 4 in. by $\frac{5}{8}$ in. trash retaining bars. They can be hoisted and lowered by an automatic hooking beam and a 30-ton crane, constructed by Sir William Arrol and Company, Limited, Glasgow, which will eventually traverse the entrances to all the intakes.

Bulkhead gates for maintenance purposes can be installed in the same slots as the screens and have been designed to operate only under balanced pressure. Downstream of each splitter wall is a free-roller intake control gate with a span of 21 ft. 3 in. and a depth of 22 ft. $10\frac{1}{2}$ in. These gates, which are electrically operated and can be controlled either locally or from the power station, are designed to operate against an unbalanced head of 74 ft. to the sill. They are of the same construction as the floodgates on the dam, a description of which was given on page 498 in the previous article, and, like them, were manufactured by Glenfield and Kennedy, Limited, Kilmarnock.

The intakes, from their entrance to some distance downstream of the control gates, are of square section, but there is a transition to a circular section 21 ft. in diameter before entering the turbines. Arrangements have been made for mounting Ottmeters downstream of the control gates so that the water flowing into each turbine can be measured for efficiency testing purposes.

TURBINES

The turbines, six of which are to be installed under the present scheme and one of which is already in operation, are of the Kaplan vertical-shaft type. They have been designed by Boving and Company, Limited, 50 Kingsway, London, W.C.2, to have an output of 21,000 h.p. each when running at 150 r.p.m., the gross static head being 73 ft. and the net head from 72 ft. to 58 ft. The first four machines have been constructed at the Clydebank works of John Brown and Company, Limited, while the fifth and sixth are under construction at the Chesterfield works of Markham and Company, Limited, who are also making all the runners.

The spiral casings of these machines are of mild-steel plate and the guide vanes, of which there are 24 with a pitch circle of 205·75 in., are of cast steel. They are provided with rubber seals along the line of closure so as to reduce the leakage when they are shut. The vanes are connected to a regulating ring on the top cover of the turbine through levers and links. The runner consists of a cast-steel hub on which five cast stainless-steel blades are mounted. Each blade is mounted on a crankpin ring which is bolted to the hub. The bearing surfaces on the ring take the radial loads on the blades, while the axial loads are carried on the journal bearings which lie between the crankpin rings and the five steel bosses on the hub.

The interior of the upper part of the hub consists of a cylinder containing a piston, which is solidly connected to a piston rod. This rod is formed with five arms with which the cranks on the crankpin rings engage through slipper blocks. With this arrangement the vertical movements of the piston rotate the runner blades. The servo-motor thus formed is actuated by oil supplied through a regulating valve in the centre of the piston rod. When this valve moves downwards oil enters above the piston so that the latter also moves downwards. The sleeve of the valve is carried down with the piston and covers the entry and discharge ports when both have travelled through the same distance. The motion of the piston is thus arrested. Similarly, an upward movement of the regulating valve imparts an upward movement to the piston.

The movements of the regulating valve are controlled by a combinator, which is mounted above the alternator. The upper end of the regulating valve rod is connected to the piston of this combinator, which is lifted by the admission of oil to its underside under the control of a small valve, and descends under its own weight when the oil is released. The movements of the governor are transmitted through a system of linkages to the combinator regulating valve and the angles of the blades are thus varied so as to give the optimum efficiency for each guide-vane opening. The turbine speed is controlled by an actuator, the movements of the servo-motor of which are transmitted both to the regulating valve and the combinator.

The internal bearing surfaces of the runner are lubricated with oil supplied from pumps attached to the lower part of the piston rod. Each downward movement of this rod forces oil through ways in the hub to the various surfaces so that the amount of lubrication depends on the movement of the runner mechanism.

A section of the runner chamber can be removed so that a blade can be taken out, and the runner and its shaft can be suspended from straps to enable the alternator rotor to be dismantled.

To enable the alternator to be run as a synchronous condenser for correcting the power factor of the system, arrangements are provided for admitting compressed air through two openings in the top covers of the turbine, thus forcing the water clear of the runner.

A connection is taken off each spiral casing into a main which runs the whole length of the station and from which water is supplied to the cooling systems of the alternators, compressors and governors. A 35-h.p. horizontal Francis turbine, which drives the stand-by governor oil pump, is supplied from the same main. All the governor pumps are interconnected by 'bus-pipes, which run the whole length of the station, so that if one fails its set can be supplied from another.

As shown in Fig. 14, the water after leaving the turbine is discharged into the tailrace through a pair of stop gates at the end of the draught tube. These gates, which were manufactured by Glenfield and Kennedy, Limited, Kilmarnock, are of the plain sliding type and have a 17 ft. 6 in. span and a depth of 14 ft. $7\frac{3}{4}$ in. They are fitted with self-adjusting blow-on rubber seals and hoisting pulleys and are designed to sustain a head of 38 ft. on the sill. They can be traversed over any of the openings and raised and lowered by four hand-operated gantry cranes under balanced hydraulic conditions.

When these gates are in position the draught tubes can be de-watered by 17-h.p. electrically-driven pumps, which were manufactured by the Pulsometer Engineering Company, Limited, Reading, and one of which is installed between each pair of tubes.

ALTERNATORS

Each turbine is directly coupled to an umbrella-type alternator, with a combined Michell thrust and guide bearing below the rotor, there being no upper bearing. The construction of the alternator will be clear from Fig. 16. As will be seen from Fig. 17, which is a view in the power station, the stator is above floor level and is completely surrounded by a square sheet-steel casing about 28 ft. across. The top of this casing is level with a gallery which runs the length of the station and on which the

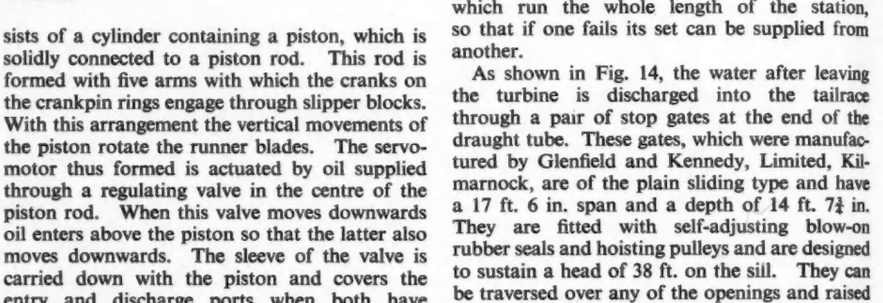


Fig. 14 Section through headrace, intake dam, power house and tailrace at Owen Falls, showing arrangement of screens, control gates and generating plant.

gauge panel, starter board, field cubicle and voltage regulator cubicle are installed.

The alternators, of which two are ready for service, have a maximum continuous rating of 16·7 MVA at a power factor of 0·8 and generate three-phase current at 11 kV and 50 cycles when running at 150 r.p.m. They were constructed by the British Thomson-Houston Company, Limited, Rugby, and were designed to a stringent specification to allow for the developments of the transmission system. They have a short-circuit ratio of 1·6, which gives a line charging capacity of 16·7 MVA at zero leading power factor with a substantial margin of excitation voltage and an output voltage range of 11 kV $\pm$ 10 per cent. As the power station is about 3,700 ft. above sea level, and the ambient temperature is high, it was necessary to keep the temperature rise at full load well below that normally permissible. The flywheel effect incorporated in the rotor is over 14 million lb.-ft.^{2}, giving an inertia constant of 4·5, so that satisfactory speed governing and stability under line fault conditions should be obtainable. Stability is further assisted by the low transient reactance of 21 per cent. and by the use of a quick-response excitation system, details of which are given below.

STATOR

The stator frame is 25 ft. 6 in. in diameter and, when wound, weighs about 55 tons. It is of fabricated construction and was made in four sections, each with a packed weight of 17 tons, to overcome transport difficulties. There are air discharge openings round the periphery and dovetail key bars are used to hold the low-loss high-ductility laminations in position. These laminations were insulated on both sides by the flash enamel process to reduce eddy currents and are clamped between segmental steel flanges. Steel fingers are welded to these flanges to support the core teeth.

The stator winding is of the double-layer lap type and is short-pitched to reduce the lower harmonics. The higher harmonics are reduced by shaping the air gap radially and by choosing an appropriate number of slots. The winding consists of two circuits in parallel per phase, all six ends being brought out by flexible leads. One turn in each coil is transposed in the end winding to reduce eddy currents.

The individual turns are of rectangular copper wire, which is covered with asbestos, while each complete turn is taped with bitumen-bonded mica and reinforced mechanically with glass tape at the ends. The coils were vacuum-dried and impregnated with bitumen, the straight portions being insulated with micafolium, which was ironed on hot by the Haefely process. Corona shields, consisting of asbestos tape treated with semi-conducting graphite paint, are provided. The top and bottom coils in each slot are divided by separators, which are shaped where necessary to accommodate thermocouples. The ends of the coils, between which spacer blocks are fitted, are taped to non-magnetic support rings. The whole winding is lashed with glass cord to prevent any movement on sudden short-circuit. Winding protection caps and air and corona shields are fitted and low-temperature heaters are provided to prevent condensation when the machine is shut down.

ROTOR

The rotor comprises a shaft, fabricated spider, rim and poles and has an outside diameter of 19 ft. 3 in., the weight being about 130 tons. The spider, which was shipped in two sections, is bolted to flanges on the shaft and to it is keyed the rim, which is built up of segmental plates. These plates are interleaved and bolted together in two sections. Owing to transport difficulties, the individual plates were shipped loose and the rim was built up on site. There are 40 poles, each weighing 1,400 lb. They are built up of laminations clamped between forged steel end plates and are held in T-headed slots in the periphery of the rim, where they are secured by tapered keys.

On the first two machines the rotor coils were machine wound, but those on the remaining units will be fabricated. To assist in cooling, a number of the turns of the machine-wound coils project at the ends, while a similar effect will be achieved on the fabricated coils by inserting sections of greater width. The major insulation is micanite, which is mechanically reinforced with varnished pressboard, and the winding is supported by moulded flanges. To damp any oscillations which may be generated by disturbances in the system, as well as to prevent hunting and to reduce harmonic voltages during unbalanced load conditions, a short-circuited winding of copper rods is fitted in semi-closed slots in the laminations near the pole faces.

Ventilation is on the closed-circuit system, fan blades being mounted above and below the rotor rim. These blades force air through ducts in the rotor and poles to the centre of the stator. The hot air is discharged through openings in the stator frame into eight air/water heat exchangers, which are arranged in pairs at the four corners of the square formed by the outer casing.

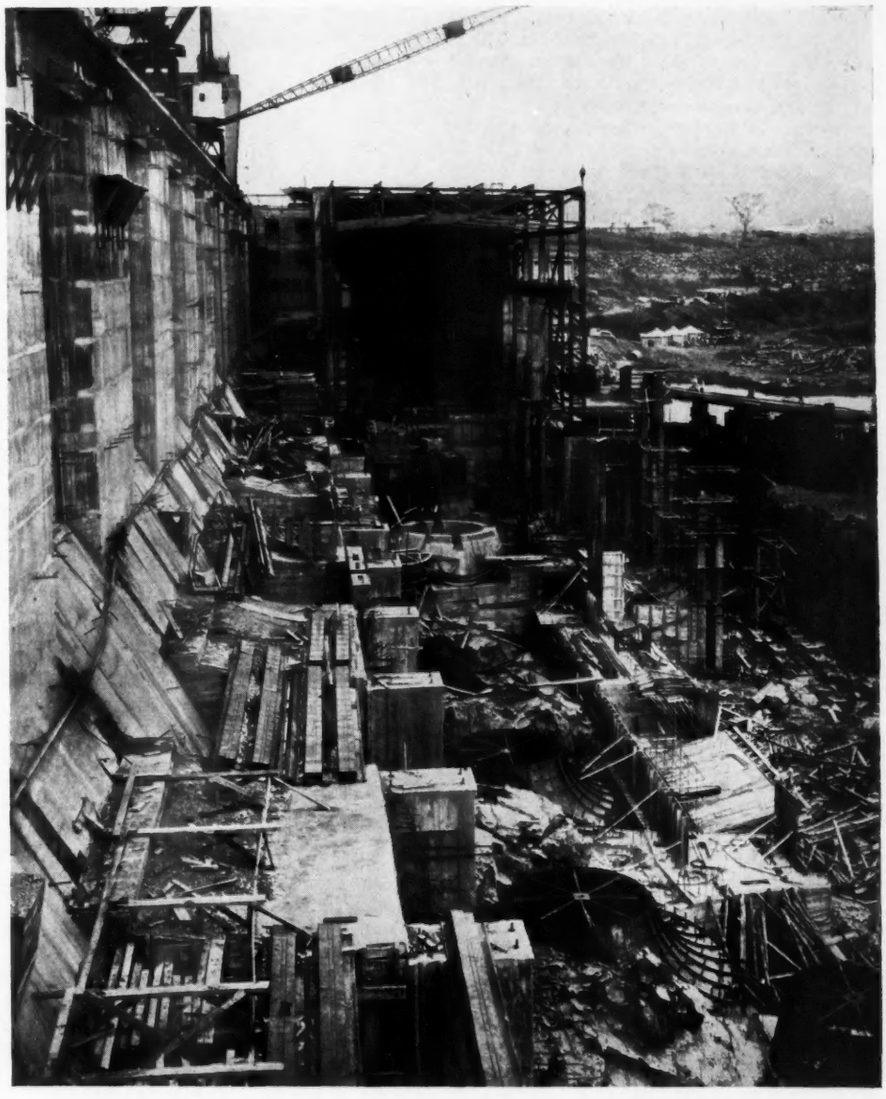


Fig. 15 View of the intake dam and power station under construction looking west.

BRAKING AND JACKING

Below the spider rim is a circle of segmental brake plates against which the combined brakes and jacks press. These brakes and jacks are mounted on the arms of the bearing bracket, as shown in Fig. 16. The pistons of both the brakes and jacks can be locked in any position by rotating a loose ring round the cylinder. When used for braking, the system is operated from one of two electrically driven compressors, which were supplied by the Westinghouse Brake and Signal Company, Limited, King's Cross, London, N.1. High-pressure oil from a portable electrically driven pump is, however, used for jacking. If it is necessary to shut down a machine quickly the brakes come into action automatically when the speed has fallen below 150 r.p.m. Alternatively, they can be applied by hand when the speed has fallen below 80 per cent. of normal.

THRUST BEARING

The bottom bracket of the set consists of a hub to which eight radial arms are bolted and houses the combined Michell thrust and guide bearing. The maximum load carried by the thrust bearing is 465 tons and, like the guide

bearing, it is submerged in an oil bath. The oil is circulated by a pump driven by a 7½-h.p. alternating-current motor through an external cooling system, sight flow indicators, a level switch and bearing thermometers with contacts being provided to give an alarm in case of breakdown. There is also a stand-by pump which is driven by a 240-volt direct-current motor and comes into operation automatically should the oil pressure fall below a predetermined value. Both these pumps were supplied by Mirrlees (Engineers) Limited, Glasgow.

The top bracket which carries the magnet frame of the main exciter and the top portion of the outer casing also consists of a hub and eight radial arms, which span the top of the stator. As will be seen from Fig. 16 only the main exciter and turbine combinator are mounted above the alternator rotor, thus reducing the overall height of the set to a minimum.

ELECTRONIC EXCITATION

The alternator excitation and governor pendulum motor are supplied from a direct-coupled direct-current generator and a separately driven exciter which is controlled by an electronic voltage regulator. The main exciter is a self-excited compound-wound machine, the magnetic circuit of which has been designed so that the variation in its flux with the speed is small. It carries three slip rings which are connected to tappings on the armature and provide a three-phase 15-cycle supply to the governor pendulum motor. A motor-operated rheostat, connected in series with its shunt field, enables initial adjustments to be made and abnormal operating conditions to be dealt with.

The auxiliary exciter is driven by a motor supplied from the main exciter and its armature is connected in series with the main exciter armature. It is arranged to buck or boost the output voltage of the main exciter, so as to give a supply at a variable voltage to the alternator field. It is in turn excited by an Amplidyne, which is directly coupled to it and which is controlled by the electronic voltage regulator.

To ensure that the main exciter voltage builds up at a suitable rate when the turbine is being started, an auxiliary field on the main exciter is connected through a contactor to the 240-volt station battery. This contactor is closed before the set is started and is opened by a relay as soon as the shunt field current of the exciter has reached a pre-determined value. An alarm circuit, incorporating voltage and speed relays, is provided to deal with the possibility of the turbine being accelerated more quickly than the voltage of the main exciter can be built up, as this would mean that the pendulum motor would not reach synchronous speed before the alternator, so that the set would continue to accelerate.

The main exciter is cooled by an electrically driven fan which is mounted between two arms of the top bracket and draws air from the alternator system. This air is returned to the alternator through filters in the underside of the exciter frame.

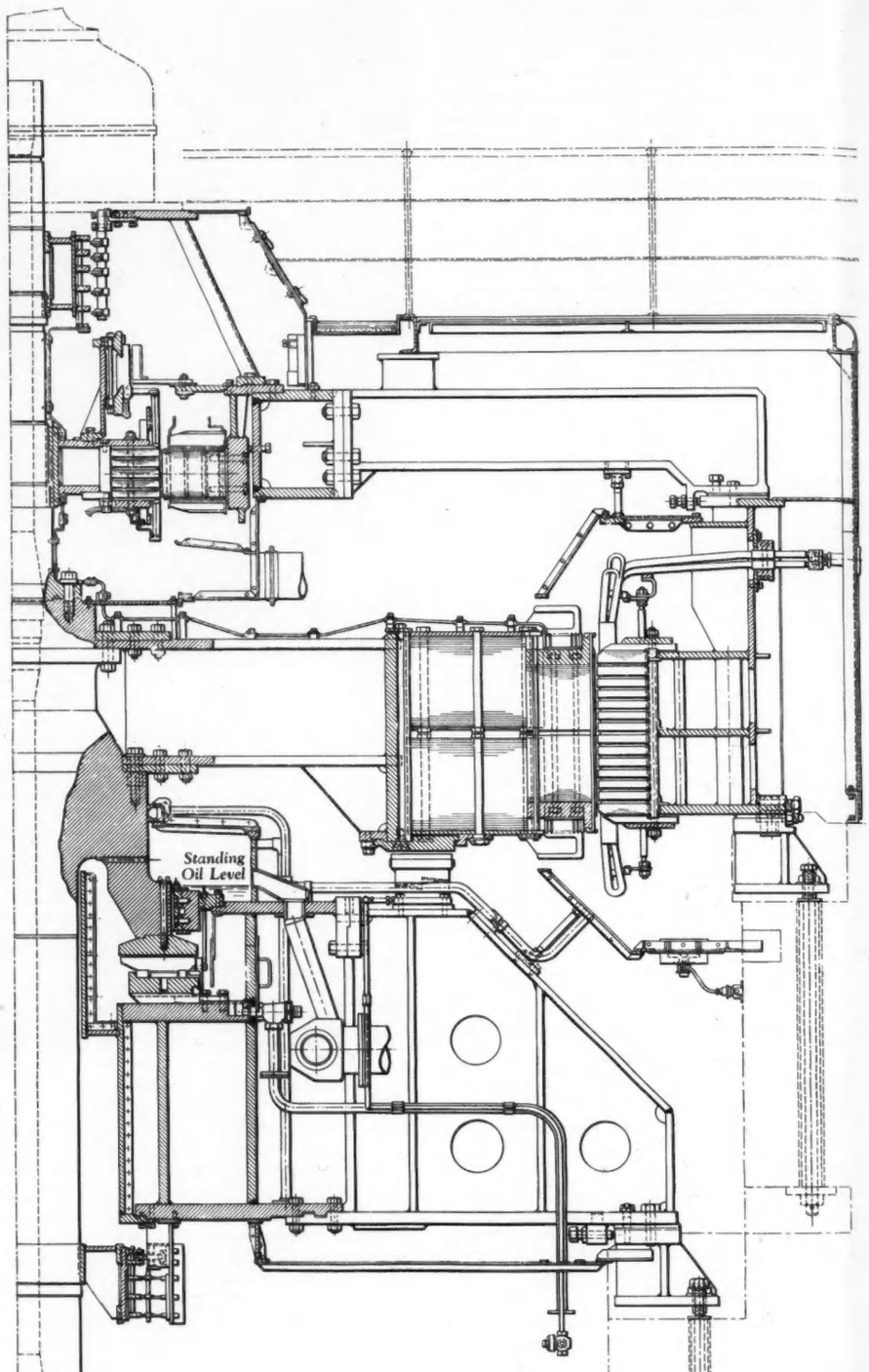


Fig. 16 Half-section through 16·7-MVA alternator, six of which are to be installed at Owen Falls under the present scheme.

VOLTAGE REGULATION

The voltage regulator is housed in a separate cubicle and employs a saturated diode, which forms part of a voltage-sensitive bridge circuit. This bridge is supplied from the alternator terminals through a potential transformer and any variation in its output is amplified, thus producing a corresponding change in the amplifier output. As a result the outputs of the Amplidyne and auxiliary exciter are altered in such a way that normal voltage is restored.

Correct voltage regulation under unbalanced load conditions is ensured by positive phase-sequence networks, and satisfactory reactive load sharing between alternators running in parallel by compensation circuits. The electronic control circuits are duplicated and automatic transfer from a unit which has developed an internal fault to a stand-by is effected by discriminating relays. In the event of an external fault, such as the failure of the potential transformer supplying the regulator, the latter is switched to hand control. Transient negative feed-back voltages from the auxiliary exciter armature, the Amplidyne armature and the Amplidyne winding are fed into the amplifier to prevent hunting and to ensure the optimum rate of recovery when the alternator load changes.

The speed of response of this system is high, since control is effected through a high-speed auxiliary exciter instead of a relatively large low-speed main exciter. In the event of line faults the full voltage is available, as the supply to the motor driving the auxiliary exciter is unaffected. An incidental advantage of the arrangement is a reduction in the overall height of the alternator, owing to the removal of the

auxiliary exciter and governor generator from their usual place on the main shaft.

ALTERNATOR CONTROL EQUIPMENT

The alternator control equipment is arranged for manual operation, although certain automatic features are incorporated. The gauge panel and the starter board form one unit, which is illuminated by fluorescent lamps. The gauge panel is divided into five sections, labelled "transformer," "alternator," "alarms and communications," "turbine" and "hydraulic," on which the appropriate controls and indicators are mounted, while the starter board houses equipment for controlling the incoming 415-volt supplies from both the 500-kVA, 33 kV/415 volt auxiliary transformer of the station, and the 50-kVA 11 kV/415 volt unit transformer, as well as the 240-volt direct-current supply and the starters for the unit auxiliaries.

OPERATING PROCEDURE

When starting from the unit supply, the stand-by oil pumps for the turbine and alternator bearings are run up and the contactors for the other alternating-current auxiliaries are closed. The turbine can then be started by pressing the "start" button on the gauge panel, thus disengaging the guide-vane lock and actuating a control switch, which runs the load limiter toward its "open" position. As the machine runs up to speed and the voltage of the unit transformer increases, the motors driving the governor and main-bearing oil pump also run up and the bearing pump automatically takes over from the stand-by pump. The stand-by pump for the turbine bearing is shut down by pressing a "stop" button, but starts automatically should the oil level in the bearing fall.

On shutting down, the voltage of the supply from the unit transformer drops and the oil pressure from the main bearing pump decreases. The stand-by pump therefore comes into action to ensure adequate lubrication while the set is coming to rest.

Alarm signals from the turbine, alternator and main transformer are indicated on the gauge panels and certain individual and group signals are relayed to the control room. A Telecommand receiver and sender switch and a telephone are provided to allow rapid communication between the turbine driver and control room, the apparatus for this purpose having been supplied by Standard Telephones and Cables, Limited, New Southgate, London, N.11.

FIRE SUPPRESSION

Fire suppression equipment has been provided for each alternator by the Pyrene Company, Limited, Brentford. It consists of a bank of cylinders from which carbon dioxide is distributed to each machine through electrically operated valves. It can be brought into action either by the circulating current relay on the alternator or by pressing an "emergency stop with CO_2" push button on the gauge panel. Similar equipment is provided for protecting the bearing oil tanks by means of a thermal detector system.

ALTERNATOR PROTECTION

Merz-Price equipment, which responds to all phase and earth faults, is installed for protecting the alternators. The relays in this system are energised from current transformers in the alternator neutrals and line terminal cubicles. These have a ratio of 1,000 to 1 and are designed to operate in 15 milliseconds. In addition, there is a triple-pole overcurrent relay with an inverse definite minimum-time characteristic, which is energised from current transformers in the neutrals. Earth fault protection is ensured by an instantaneous relay of the attracted armature type with a sensitivity of 7 amperes primary current. This relay is energised from a 100/1 ampere current transformer, which is connected in the earthing resistor circuit. This resistor, which has a value of 63·5 ohms, is employed to earth the alternator neutral and limits the earth fault current to 100 amperes at 11 kV.

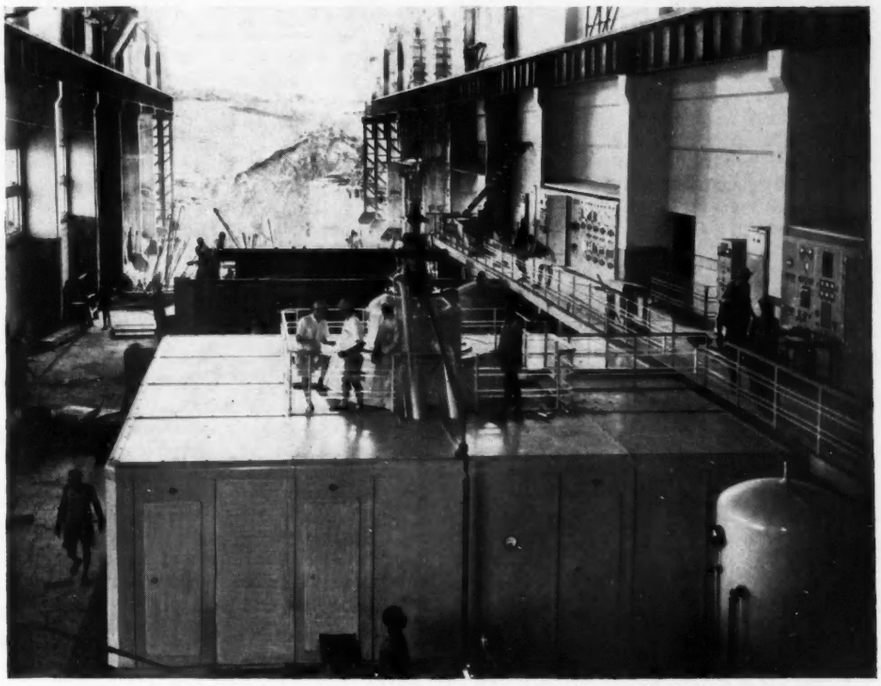


Fig. 17 Interior of power house from the visitors' gallery with the control boards on the right.

The trip relays which, like the rest of this protective equipment, were manufactured by the General Electric Company, Limited, Kingsway, London, W.C.2, are all equipped with re-set coils, so that they can be restored to working order from the control room.

ELECTRICAL LAYOUT

As is shown diagrammatically in Fig. 18, the first four alternators at Owen Falls will each be solidly connected to a 16·67 MVA, 11/33-kV transformer and thence through switchgear to double 33-kV bus-bars from which feeders operating at that voltage run to Tororo, Nyanza and Njeru. These bus-bars will also be connected to feeders to Kampala through two 7·5-MVA, 33/66-kV transformers, which are controlled by switchgear on the 33 kV side only; and to two auxiliary transformers for supplying the station equipment. In addition, they are connected through two 20-MVA, 33/132-kV inter-bus transformers to double bus-bars. These bus-bars will be also supplied from the two alternators which will complete the installation in the station through 16·67-MVA, 11/132-kV transformers and from them overhead lines will be run to Tororo and Kampala. These lines are now being erected by British Insulated Callenders Construction Company, Limited, 21 Bloomsbury-street, London, W.C.1.

The main 16·67-MVA 11/33-kV transformers were manufactured by Bruce Peebles and Company, Limited, Edinburgh. They are of the outdoor oil-immersed water-cooled core type with vertical legs. These legs are provided with transverse oil ducts. The 11-kV winding is connected in delta and is separated from the 33-kV winding by an insulating cylinder and oil ducts on each side. Good oil circulation and high insulation strength between the windings and earth are ensured by spacers. The windings consist of disc coils with interlocked spacers, the latter being so arranged that, while they are free to slide when the coils are being tightened, they do not work loose in service.

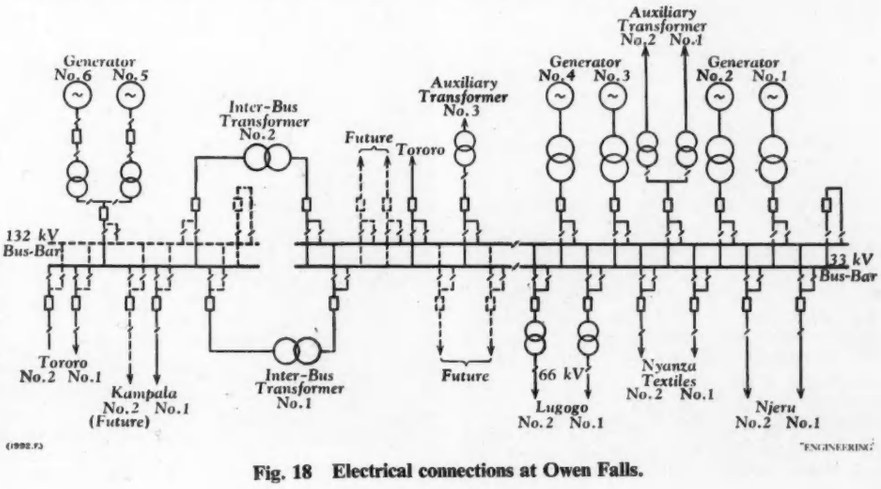


Fig. 18 Electrical connections at Owen Falls.

Cooling is effected by two forced-oil coolers, one of which, together with its totally-submerged electrically-driven pump, is installed at each end of the unit. Each of these pumps forces oil through a Serck cooler, and is capable of dealing with full-load requirements. The cooler itself consists of a nest of small-bore tubes in a jacket through which water is circulated. A valve on the outlet of the cooler ensures that the oil pressure exceeds the water pressure and, if there is any alteration in that condition, warning is given by a differential pressure gauge with alarm contacts.

The transformers are protected by what is virtually a Merz-Price circulating current system with a bias feature. This system automatically increases the setting of a differential relay in proportion to the value of the load and the through-fault current. The relays are responsive to phase and earth faults on either side of the transformer and are energised by current transformers in the 33-kV circuit-breakers and in the generator line terminal cubicle. Back-up protection is provided by a triple-pole inverse definite minimum time earth fault relay, which is energised from a current transformer in the neutral. Over-voltage relays have also been installed to trip the set in cases of excess voltage rise due to capacitance when switching the long overhead lines, while Buchholz relays and winding and oil temperature devices are fitted.

This protective equipment was also manufactured by the General Electric Company, Limited.

The two 7·5-MVA, 33/66-kV transformers, which were manufactured by Bruce Peebles and Company, Limited, are of the outdoor oil-immersed naturally-cooled type and are provided with an electrically-operated on-load tap changer on the 33-kV side to give a voltage variation of $\pm$ 10 per cent. in 16 steps of 1¼ per cent. each. Overcurrent protection is provided by triple-pole relays with inverse minimum time characteristics. The transformers are also provided with earth fault protection on the 66-kV side and restricted fault protection on the 33-kV side, as well as with Buchholz relays and alarms operated by the winding temperature.

SWITCHGEAR

The 33-kV switchgear was made by the General Electric Company, Limited, and is installed in the outdoor substation shown in Fig. 19. It consists of twelve oil circuit-breakers and 43 rotary isolators operating at the same voltage. There are also two 66-kV rotary isolators.

The 33-kV circuit-breakers are mounted on a rolled steel framework, within which is the tank lowering gear. This gear is operated by a handle, the arrangement being such that each tank can be lowered separately. The top is a fabricated steel box and supports the Bakelised paper condenser bushings on which the fixed contacts and the terminals for the inside connections are mounted. It also provides accommodation for the moving contact mechanism and current transformers (which are enclosed in self-contained compartments), besides constituting an expansion chamber for the arcing products. The rectangular tank is bolted to the underside of this enclosure and is lined with insulating plates. The arc control pots are of the side-blast type and consist of a cylindrical shell of synthetic-varnish bonded fabric, which surrounds the main contacts. The lower end is closed by a ring between which and a second ring (that is electrically connected to the fixed contact) is a stack of plates of arc-resisting material. These plates are shaped to form a series of internal cavities and lateral vents, to the design of which the action of the pot is due. The arcing contacts in the pot can carry the load current so that no external contacts are fitted. The fixed contacts consist of self-aligning fingers which are bolted to a cast copper contact block on the lower end of the bushing stem. These contacts are arranged in sets of four so that they make a circular line contact with the moving contact, the necessary pressure being provided by springs. The moving contacts are fitted with replaceable tips of tungsten-copper alloy, which has a high resistance to burning. The moving contact stems are carried on a cross-bar of copper alloy, which is attached by insulating plates to a tubular member sliding in a fixed tube so as to form a dash pot. The contacts are operated by a lever, which is connected to the moving tube by a double link and by a rod which is actuated by the operating mechanism.

The closing and tripping mechanism, control switches and other apparatus are mounted on a frame on the front of the structure and are covered by a weather-tight housing.

The rotary isolators on the bus-bars, feeders, bus couplers and voltage transformers are of the double-break type with a current carrying capacity of 400 amperes at 33 kV, except in the case of those on the bus couplers for which it is 800 amperes. Each pole consists of three stacks of insulators, two of which carry the fixed contact jaws and the third the moving blade, which is mounted on a bearing in the centre of the base. To open the isolator this stack is rotated in a horizontal plane by a system of levers and rods, so that the moving blade is disengaged and a double break action obtained.

The isolators on the 66-kV feeders are of the vertical break rotary type with earthing switches and have a current carrying capacity of 400 amperes.

CONTROL BOARD

The present control board, which was also supplied by the General Electric Company, consists of 28 panels arranged in L formation. When, however, the station is completed the additional panels will be placed so that the whole forms a U. The board has an overall height of 7 ft. 9 in. and is of pressed steel construction. The instruments are mounted at the top of the panels and below them is an automatically controlled mimic diagram, which is equipped with discrepancy-type control switches. These switches, which combine the functions of a control switch and a semaphore showing the position of the circuit-breaker, consist of a cylindrical casing which is fixed to the panel and a Bakelite moulding which carries the contacts. The switch is actuated by a combined operating handle and lamp housing, which is fitted inside the casing. It forms an integral part of the mimic diagram, and its position is indicated by a bar which acts as an operating handle. The lamp, which lies immediately behind the Perspex dome of its housing, is connected to the switch contacts and to the auxiliary contacts of the circuit-breaker, so that it is only illuminated when the position of the latter does not agree with that shown on the diagram.

In operation the switch handle is rotated to correspond with the required position of the circuit-breaker. As the position of the breaker then no longer agrees with that of the control switch, the lamp shows with a steady glow or flicker. The actual tripping or closing of the breaker is initiated by pushing the handle inwards against a spring, while as soon as either of these operations has been completed the lamp is extinguished, since the position of the circuit-breaker again corresponds with that of the control switch handle.

Should the circuit-breaker trip, automatically the lamp lights and audible alarm is given. The lamp is then extinguished and the alarm silenced by moving the control switch to its open position.

The 132-kV switchgear, as shown in Fig. 18, through which the outgoing feeders operating at that voltage will be supplied, is being manufactured by A. Reyrolle and Company, Limited, Hebburn, Co. Durham.

The consulting engineers for that part of the work at Owen Falls which is described in the above article were Messrs. Kennedy and Donkin, 12 Caxton-street, London, S.W.1.

The principal contractor for the civil engineering work was the Owen Falls Construction Company, the constituent members of which included: Christiani and Nielsen, Limited, 54 Victoria-street, London, S.W.1; Dorman, Long and Company, Limited, Middlesbrough; J. L. Kier and Company (London), Limited, 7 Lygon-place, London, S.W.1; and Edmund Nuttall, Sons and Company (London), Limited, 22 Grosvenor-gardens, London, S.W.1; as well as the following Dutch firms: N.V. Hollandsche Beton Mij, N.V. Internationale Gewapendbeton Bouw, N.V. Nederlandsche Aanneming Mij. v.h. Fa. H. F. Boersma, and N.V. Nederlandsche Beton Mij. Bats.

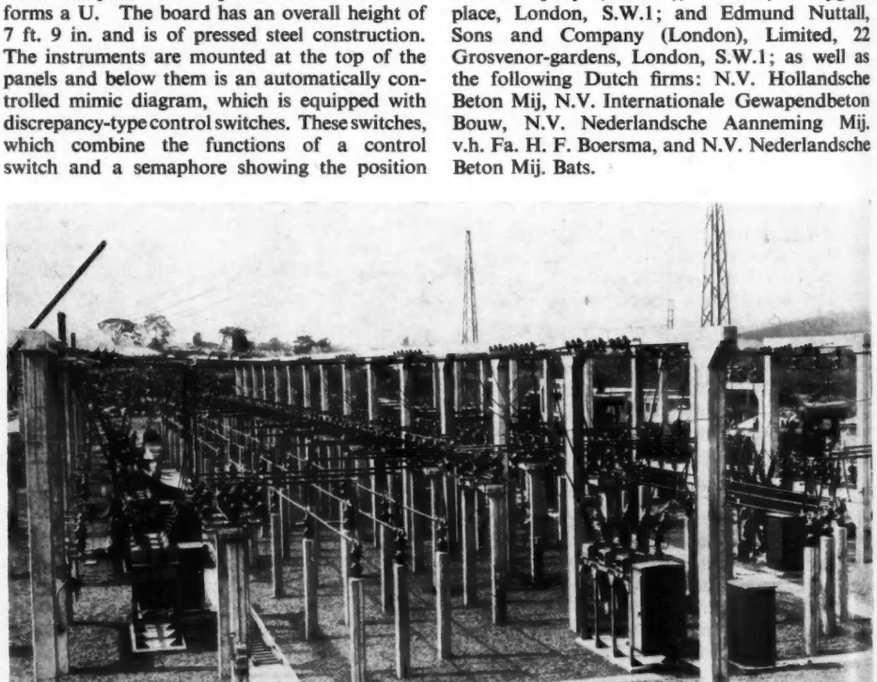


Fig. 19 The outdoor switching station.

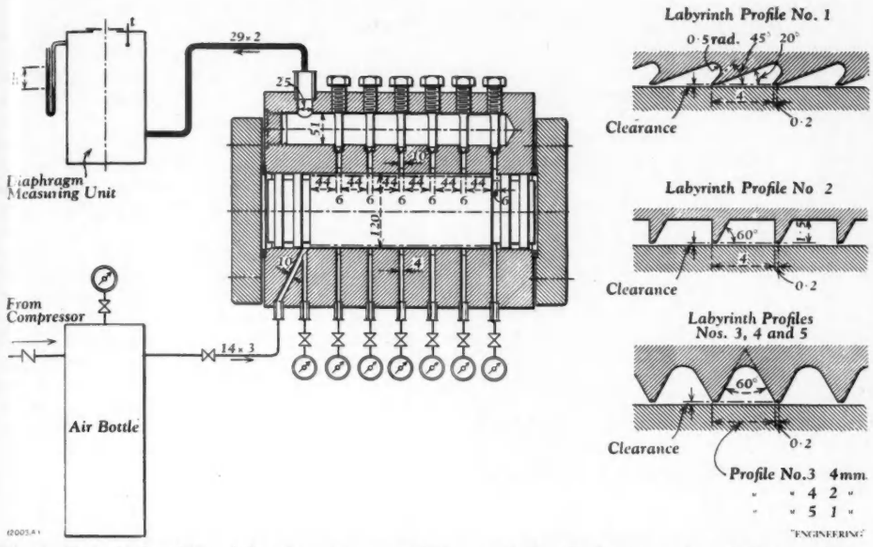


Fig. 1 Test rig for determining the pressure variations and the slip losses past a stationary piston with labyrinth seals. Of the five labyrinth profiles investigated, the triangular type with small pitch (No. 5) proved to be the most effective.

THE OIL-FREE RECIPROCATING COMPRESSOR

PISTON RINGS REPLACED BY LABYRINTH SEALS

*By F. O. Walti**

Sealing the piston of an oil-free reciprocating compressor can be accomplished by labyrinth seals, so making it possible to dispense with piston rings which require lubricating by an oil film. The machine is then capable of dry operation.

* Chief engineer, Sulzer Brothers, Winterthur, Switzerland.

The principle of labyrinth seals depends upon countering the flow of gas through the gap between the piston and the cylinder wall by such a resistance, in the form of a long succession of throttling points, that the quantity of leaking gas is kept within admissible limits.

This method of sealing, like that of piston rings, is a compromise, in the sense that even the best labyrinth seal will not completely prevent slip. However, it can be shown by theoretical investigation and practical measurements that in very many cases the curve representing the losses through a labyrinth seal approaches very close to that of the piston ring. It is known that in a straight labyrinth seal of given length the gas loss at first decreases rapidly with an increasing number of throttling points till, after the optimum number has been reached, it remains constant or even rises slightly. Many of the fundamental laws applying to the throttling action of labyrinths have already been established.

The absence of piston friction—which differs according to the design and size of the compressor but may exceed 5 per cent. of the total for the whole machine—leads to a power saving and to longer life, so that an overall comparison may well prove to be in favour of the labyrinth seal and the oil-free compressor. From the economic standpoint, the saving of oil and the reduction in replacements (because of the lessening of wear due to friction) must also be taken into account.

The chemical industries, particularly the brewing and foodstuffs industries, have long required a machine which would permit them to compress air and other gases without contaminating them with oil, dirt and an unpleasant "machine" odour. Where large quantities of gas have to be compressed to a moderate pressure only, this requirement can be fulfilled with turbo-compressors or even with simple bellows machines or rotary blowers. Nevertheless, there are many applications which clearly need a reciprocating compressor so long as oil lubrication can be avoided, and for this purpose the oil-free compressor was developed.

DEVELOPMENT OF LABYRINTH FORM

The manufacture of oil-free compressors was taken up on a large scale by Sulzer Brothers in the middle years of the thirties. The theoretical data needed were obtained from tests on stationary equipment. In the test rig shown in Fig. 1 pistons of slightly different diameters carrying labyrinths of five varying forms were fitted

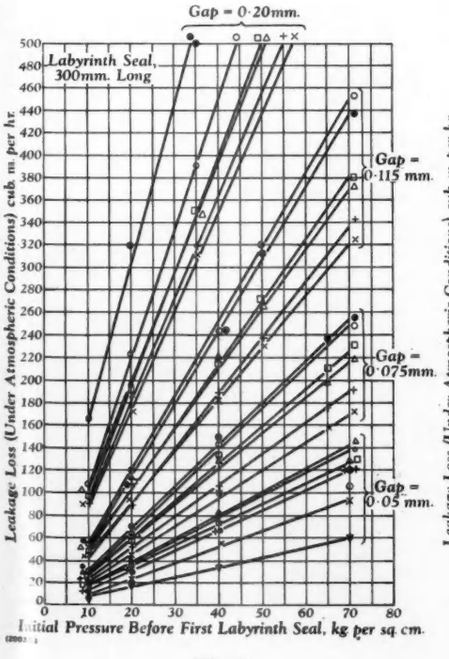

Gap = 0·20mm.
Labyrinth Seal, 300mm. Long
Gap = 0·115 mm.
Gap = 0·075mm.
Gap = 0·05 mm.
Leakage Loss (Under Atmospheric Conditions) cub. m. per hr.
Initial Pressure Before First Labyrinth Seal, kg per sq. cm.

Fig. 2

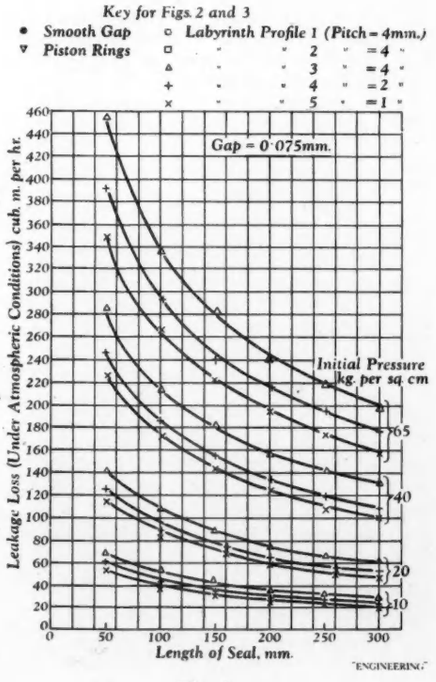

Key for Figs. 2 and 3
Smooth Gap
Piston Rings
Labyrinth Profile 1 (Pitch = 4mm.)
" " 2 " = 4 "
" " 3 " = 4 "
" " 4 " = 2 "
" " 5 " = 1 "
Gap = 0·075mm.
Initial Pressure kg. per sq. cm
65
40
20
10
Leakage Loss (Under Atmospheric Conditions) cub. m. per hr.
Length of Seal, mm.
"ENGINEERING"

Fig. 3

Fig. 2 Slip losses of a labyrinth 300 mm. long as a function of pressure drop, gap width and labyrinth profile. For purposes of comparison, the values for a smooth gap and for a piston with simple rings are also given. Fig. 3 Slip losses of labyrinth with triangular profiles of various pitches as a function of pressure and length of seal.

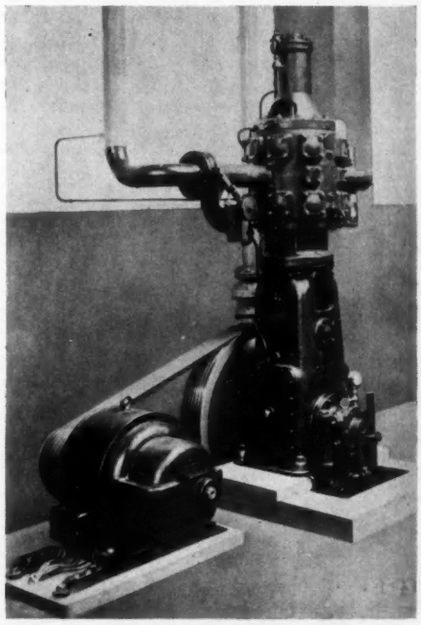


Fig. 4 Original design of the oil-free air compressor. Discharge, 400 cub. m. per hr. (235 cub. ft. per min.); delivery pressure, 3·5 kg. per sq. cm. abs. (50 lb. per sq. in. abs.).

in a cylinder provided with pressure-measuring points along its whole length. The pressure drop and the slip losses were then determined under various conditions, the rig permitting the changes in pressure over the whole length of the piston to be registered. The pressure, gap width and labyrinth form were then varied in order to finding the most favourable combination. The results are shown in the family of curves shown in Figs. 2 and 3, on page 533.

As was to be expected, it proved that losses depend to a large extent on the width of the gap between the piston and the cylinder wall. Just how far this gap could be reduced could not be ascertained from stationary tests and the limiting values had to be measured later on the piston of a running machine. It was established that the form of the labyrinth has comparatively little influence on the throttling effect, but that one of the most favourable forms was the easily machined profile of a very fine triangle, such as profile No. 5 in Fig. 1, cut into the piston wall after the fashion of a fine screw thread.

The oil-free compressor was developed by stages. It was an obvious plan to begin by trying out the single-stage air compressor thoroughly at moderate pressures. Breweries were among the earliest purchasers. The first machine, which was supplied in 1935 to the Hürlimann Brewery in Zürich, shown in Fig. 4, on page 533, had all the essential features of the later models. Among these features are: the sturdy piston rod with two guides on which the light piston runs through the cylinder without vibration, safely and quite centrally, so that with a piston clearance of about 0·1 mm. no contact or friction, and thus no wear, occurs; the special form of the water-cooled cylinder, which ensures that, in spite of the non-uniform heating of the regions near the suction and discharge valves, no bending and axial displacement need be feared; the reliable protection of the cylinder parts coming into contact with the air or gas compressed from the entry of oil from the forced-lubricated bearings, the crosshead or the piston-rod guide; and finally the comparatively high speed, which has proved to have a favourable influence on the labyrinth effect.

In the development of these compressors, as in all technical advances, the aim has been to build better and more efficient machines. The progress made in this direction since the construction of the first single-stage compressor is apparent from a comparison of the first unit, illustrated in Fig. 4, with the latest model as shown in Fig. 5. The upper piston-rod guide, which had to be lubricated - involving a certain increase in cost as well as complicating the problem of keeping oil out of the cylinder – has been dispensed with in many later designs and replaced by a double guide at the bottom. The oil-free compressor in a variety of sizes has meanwhile found its way into numerous breweries and industrial undertakings in Switzerland and elsewhere.

The compression of steam in this type of machine enables factories to obtain small quantities of heating steam at high pressures, in many cases making it unnecessary to install an additional boiler. The steam is taken from existing low-pressure boilers and raised to the desired service pressure without any risk of contamination. A unit of this kind is shown in Fig. 6; it forms part of the fat-splitting plant of a Swiss soap factory.

INCREASED DELIVERY PRESSURES

The next step was the two-stage compressor, which can be used for pressures up to about 25 atmospheres, or 350 lb. per sq. in. The differential piston initially adopted was later abandoned in favour of a compact two-throw design. The compressor shown in Fig. 7 is a typical example of this series.

After the two-stage machine had successfully passed its trials, the advent into the field of high pressures proper began. The pressure range was increased directly from 25 to over 100 atmospheres and the apparently impossible suddenly became a constructional possibility. The building of high-pressure machines was favoured by the fact that, with oil-free operation, higher piston speeds and greater pressure differences per stage are admissible than with lubricated machines, as little attention need be paid to hot running and none to friction. In the lower stages compression ratios of 1 : 5 are frequent.

COMPRESSING OXYGEN IN STEELWORKS

The design must of course be adapted to the properties of the gas handled, for even if the problem of lubrication no longer exists, the design involves a number of other factors which must be taken into account.

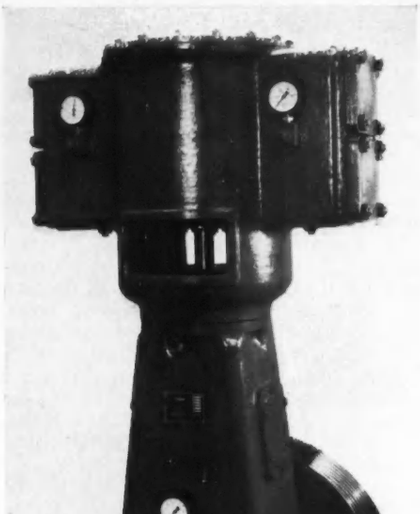


Fig. 5 Single-stage, single-acting oil-free air compressor of modern design. Discharge, 670 cub. m. per hr. (395 cub. ft. per min.); delivery pressure, 1·4 kg. per sq. cm. abs. (20 lb. per sq. in. abs.). The valve pockets on the cylinder are required to handle the large quantity of gas at low pressure.

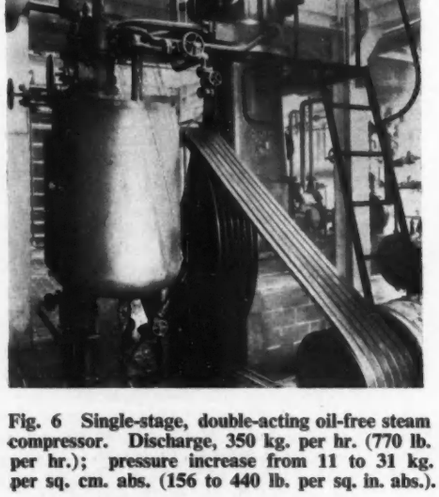


Fig. 6 Single-stage, double-acting oil-free steam compressor. Discharge, 350 kg. per hr. (770 lb. per hr.); pressure increase from 11 to 31 kg. per sq. cm. abs. (156 to 440 lb. per sq. in. abs.).

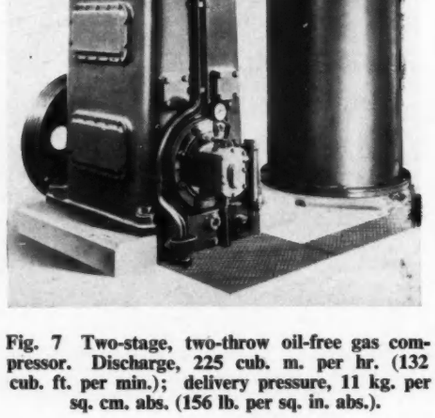


Fig. 7 Two-stage, two-throw oil-free gas compressor. Discharge, 225 cub. m. per hr. (132 cub. ft. per min.); delivery pressure, 11 kg. per sq. cm. abs. (156 lb. per sq. in. abs.).

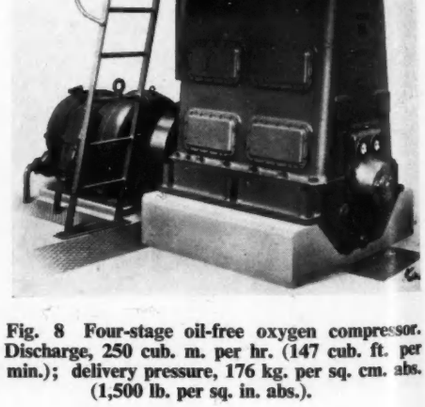


Fig. 8 Four-stage oil-free oxygen compressor. Discharge, 250 cub. m. per hr. (147 cub. ft. per min.); delivery pressure, 176 kg. per sq. cm. abs. (1,500 lb. per sq. in. abs.).

The oil-free compressors appeared on the market at a time when many industries all over the world, and particularly steelworks, were beginning to make extensive use of oxygen plant. In the oxygen compressor shown in Fig. 8, however, an unexpected difficulty was encountered, in that wear of the labyrinth piston occurred above a certain pressure limit, causing trouble in service. Even if this means that only certain parts, such as the piston of the top stage, have to be replaced somewhat more often than otherwise, this fact is a stimulus to research and to the further development of the existing designs. It may already be claimed also that the replacement of the piston in the top stage of the oil-free compressor requires little more time and trouble than the fitting of new leather or fibre cups in water-lubricated oxygen compressors of orthodox design.

The considerably higher speed of these compressors favourably affects space requirements, weight and cost. A standard induction motor can usually be adopted for the drive and coupled directly to the flywheel. It may often be an advantage of itself that the machine is dry in operation so that the process of drying the compressed oxygen or other gas is unnecessary.

These types of compressors are still in the early stages of development and there are still a number of attractive features which have to be attained; for example, the reduction and more accurate control of piston clearance, the compensation of expansion and heating effects and the determination of the best materials for the purpose. Pistons of light alloys, such as are often used for low-pressure compressors to keep down the inertia forces and, when slowly run in, lap themselves to the correct piston diameter, are out of the question for high-pressure compressors. Instead, extremely hard special steels or alloy steels have to be adopted, and these have to be machined very accurately to the required dimensions.

LIMITING TEMPERATURE WITH CHLORINE

For the compression of chlorine it is important not only to select the right material but also to limit the compression temperature. It has been shown that dry and completely pure chlorine can be compressed without difficulty in the oil-free compressor, provided that the pressure ratio is kept low by the employment of a sufficient number of stages and that the temperature of the gas at no point exceeds about 75 to 80 deg. C., during its passage through the machine. It is not particularly difficult to fulfil this requirement, and it is therefore probable that the compressors employing sulphuric-acid lubrication, which have been used hitherto, will soon disappear from the chlorine factories to be replaced by unlubricated machines. Instead of operating with a low intial pressure and liquefying the gases by refrigeration, it will be quite possible to carry compression to such a level that the condenser might be operated on mains water. The final pressure of 12 to 15 atmospheres needed for this purpose can be obtained quite easily in three or four stages in the dry reciprocating compressor, whereas the blowers so far adopted were not suitable for pressures above two or three atmospheres.

It is true that the chlorine compressor has still to prove its claims in continuous industrial service and that its final design has yet to be determined but first tests have demonstrated the serviceability of the labyrinth piston when combined with a somewhat modified piston-ring seal. Losses of chlorine and the entry of moisture into the cylinder can both be prevented with the aid of a sealing gas.

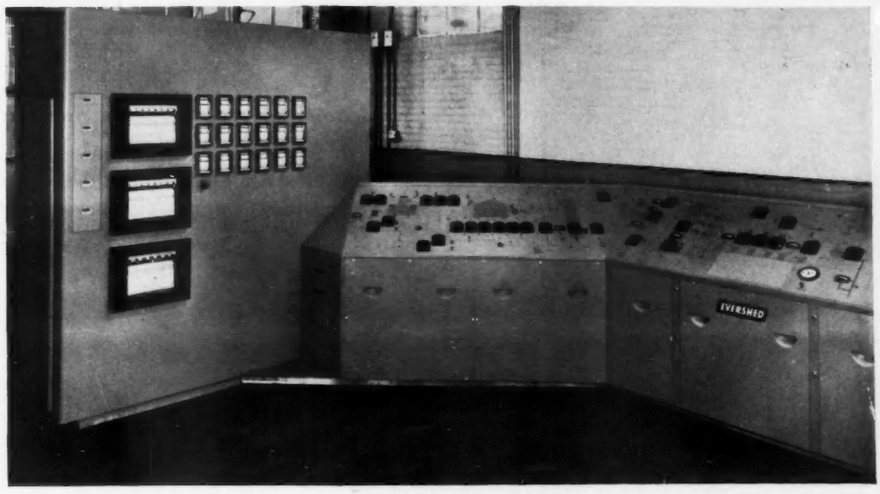


Fig. 1 The left half of the control desk. The cubicle at the end houses the electronic units and the recording instruments; on the desk are the process controllers and setting indicators.

CONTROLLING OIL REFINERIES

ELECTRONIC SYSTEM GIVES EASY ADJUSTMENT AND SERVICING

Automatic electrically-operated control units have been made by Evershed and Vignoles, Limited, Acton-lane Works, Chiswick, London, W.4, for two crude distillation units built for the Anglo-Iranian Oil Company's refinery at Aden. Each unit is capable of producing 60,000 barrels a working day. The electrical operation is a departure from the more conventional pneumatic system, and has several advantages over it. Indication and response are almost instantaneous and any time-lag is therefore eliminated; the system is more flexible as the piping is replaced by electric cables which can be run for long distances; and it is a simple matter to obtai an nelectrical response which varies linearly with the change. Fig. 1 shows the left half of the control desk as assembled at the works.

Each desk is designed to fit into a bay window overlooking the plant it controls; on the desk itself is a mimic diagram with all the indicators fitted into it in their actual positions. At each end is a cubicle carrying the recording instruments and containing the electronic control units. The latter are all standard plug-in units, of three types only, which reduces the number of spares required and also simplifies servicing. The setting controls are on the indicating units on the control desk and may be reached by opening a cover plate. One of these indicator-controllers with the cover plate removed is shown in Fig. 2. Each indicator-controller is divided into two parts, one for automatic and the other for hand control, with a change-over switch below; this also has a third position for servicing. A hand-adjusted red pointer shows the desired setting and a black pointer marks the actual value. A Honeywell-Brown selector is used to connect the temperature-measuring points to the indicator and the point selected is marked by a lamp on the mimic diagram. Some 40 controllers are used in each unit, covering flows, pressures, levels and temperatures. Specific gravities are also indicated and there are alarm signals for danger points.

Fig. 2 A process controller and indicator; the three adjustments at the top control the setting current in the electronic comparator units, and are normally covered in.

TRANSMITTING SYSTEM

The principle of operation of the transmitting system for all measuring elements is shown in Fig. 3, page 536. The transmitter 1 is a torque-balancing device in which the torque exerted by the originating movement is balanced by the torque of a coil operating in the cathode circuit of a thermionic valve. The balancing coil is connected in series with simple milliammeter movements in indicators, recorders and controllers, which therefore receive signals proportional to the measured quantity. When in balance, a contact connected to the grid of the valve and carried by the balancing coil is in a neutral position between two fixed bias contacts, the voltage on the grid being maintained by a storage capacitor between grid and cathode.

Any unbalance created by a change in the quantity being measured causes the grid contact to touch the positive or negative bias contact, thereby raising or lowering the plate current until the system is again in balance. The transmitter compensates automatically for any

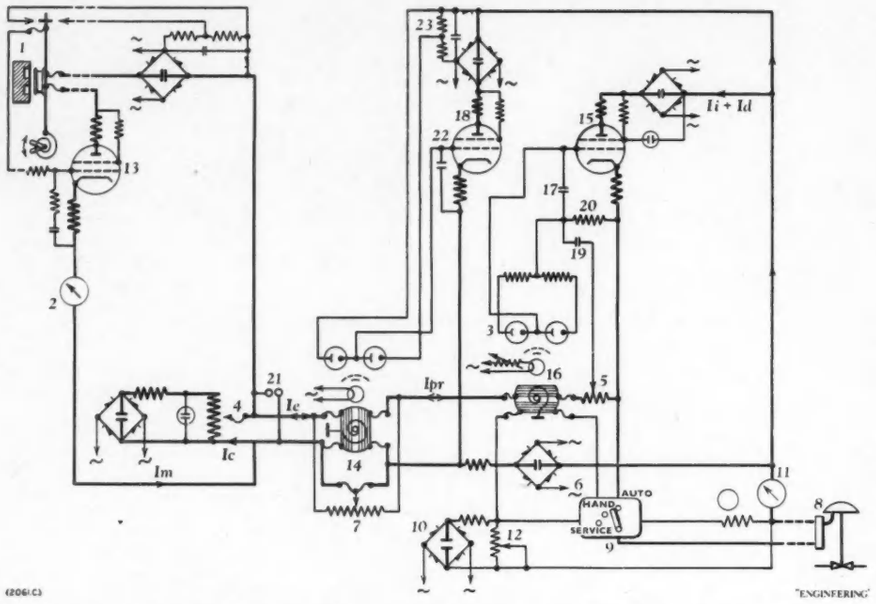


Fig. 3 Circuit diagram of control system. The electromagnetic relay (1) is also shown in Fig. 4.

change in supply voltage, circuit resistance, or frequency.

Signals ranging from 0 to 30 milliamperes, from the measuring elements are transmitted to the controllers. There, they are compared with the signal for the desired setting and any necessary correcting signal is sent out to the operating mechanism. Three separate elements are involved in the correction signal (the unit being therefore known as a three-term controller): first a correction proportional to the error-current, second, a time-integral of the error-current, and third, a correction by the time-rate of change of the error-current. These three are combined to form the output signal to the torque-balancing coil which forms part of the regulating unit and operates against a permanent magnet. This is shown in the controller-circuit diagram, Fig. 3, and in the valve control relay, Fig. 4. As may be seen in the circuit diagram, Fig. 3, above, the proportional and integral units are current balances and operate in a similar manner to the transmitters. The voltage applied to the grid of the appropriate valve, however, is modified by unbalancing the light distribution on two photo-cells forming part of a bridge.

The desired value is established by a current derived from a neon-stabilised supply, the setting being controlled by a variable resistor 4. It will be seen that this current (Ic) provides the reference with which the measuring current (Im) is compared.

PROPORTIONAL ACTION

The currents Ic and Im are compared by feeding them in opposition through one winding of a double coil movement 14. A change in the measuring current deflects the movement and unbalances the photo-cell bridge connected to the grid of the valve 18. This plate current passes through a second winding of the movement 14 and the coil of the valve positioner 8. The current required to re-balance the bridge is the difference between the desired and measured currents and represents the error in the system.

Another current, derived from the rectifier 6, is fed in opposition through the same circuit, producing a " centre zero " current in the second winding of the movement 14, and a current Ipr, which can change in magnitude and direction. The sensitivity of valve response or proportional band is varied by a differential shunting resistance between the coils of the movement 14, the tapping point of which may be adjusted to give band widths from 2 to 600 per cent.

INTEGRAL AND DERIVATIVE ACTION

The integral of the error is obtained by feeding the current Ipr through a movement 16, the deflection of which disturbs the balance of light falling on two photo-cells. The photo-cells form part of a current bridge, the output of which charges the capacitor 17 connected between the bridge and the cathode of a valve 15. The plate current is passed through the coil of the valve positioner. The voltage across the capacitor represents the integral of the error with respect to time. The integral time is governed by the intensity of light falling on the two photo-cells and may be varied by a resistor included in the lamp circuit which is calibrated from 0·2 to 60 minutes of integral time.

In order to produce a further component dependent on the rate of change of error, the current Ipr is also caused to pass through a resistor 5 which is connected to a circuit including a capacitor 19 and a resistor 20. During an error-current change, the voltage across the resistor 5 produces a charging current to the capacitor 19, and, therefore, a voltage across the resistor 20 which is applied to the grid of the valve 15. A derivative component is thus added to the integral component. The resistor 5 is variable and is calibrated from 0 to 10 minutes of derivative time.

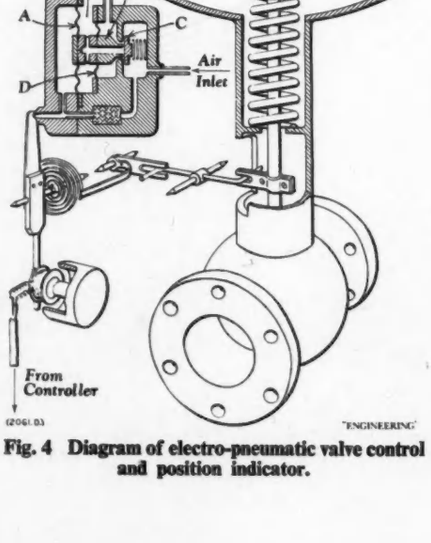


Fig. 4 Diagram of electro-pneumatic valve control and position indicator.

VALVE CONTROL

Pneumatically-operated valves are used to control the flows in the various pipelines; these are fitted with the Evershed and Vignoles electro-pneumatic relay which adjusts the position of the valve to the controller setting. The principle of operation is shown in the diagram, Fig. 4.

The relay has a pivoted beam at one end of which is a coil operating in the field of a permanent magnet through which coil the signal from the process controller passes. At the other end of the beam is a flapper operating in conjunction with the nozzle of a low-bleed type air relay, the output from which is fed to the diaphragm head of the valve under control. The beam is attached to the inner end of a spiral spring which exerts a turning moment about its pivots, while the other end of the spring is connected to an adjustable feed-back lever fitted to the valve stem.

When the system is in balance, the spring torque is equal to that produced by the moving coil which in turn is proportional to the controller output; any change in this output will, therefore, unbalance the beam, causing a movement of the flapper with respect to the air-relay nozzle. This will vary the air flow through the nozzle and hence the pressure on the primary diaphragm A, which will move, carrying with it the hollow plunger B operating in conjunction with the spring-loaded valve C. Increase of pressure on A will connect the diaphragm head of the controlled valve to the air pressure inlet, and decrease in pressure will connect it to atmosphere.

The action continues until the force on the secondary diaphragm D equals that on A when a state of balance is restored at a new output pressure, and both B and C are closed. Variation of pressure on the diaphragm will move the valve stem, carrying with it the feed-back lever which corrects the unbalance between the spring and moving-coil torques, and a state of balance is restored with the valve stem in a new position. As movement of the valve stem bears a linear relationship to the spring torque operating on the beam, it will be seen that the valve position is directly proportional to the input signal irrespective of air pressure and friction loading upon the valve. A change from 0 to 15 milliamperes from the controller is equivalent to 3 to 15 lb. per square inch on the diaphragm.

Instruments on the end cubicles of the control desk integrate the measured quantities and so give total flows, etc.; Evershed and Vignoles miniature recorders are used to indicate trends in the processes. These have a chart width of only 2 in. but can be fitted with a range adjustment which allows the use of a false zero; thus the sensitivity can be the same as that of an instrument with a 10-in. chart working to a true zero.

These control desks are a development of those previously made by the company for other installations, but are more compact and easily serviced. They were constructed to the requirements of E. B. Badger and Sons, Limited, 99 Aldwych, London, W.C.2, and will be installed in the Aden refinery by the Bechtel-Wimpey organisation.

THE PHYSICAL SOCIETY'S EXHIBITION

Concluded from page 473

At a recent meeting, the Council of the Physical Society regretfully decided that the exhibition could not be held in future at the Imperial College. In spite of the willing co-operation of the Rector and Governors, the space that can be made available has become less and less and the severance of the long and happy connection between the College and the Society is thus unavoidable. Accordingly it is proposed to hold the 1955 exhibition at the Royal Horticultural Hall, and arrangements are being put in hand. This year's exhibition was concluded on April 13.

THICKNESS GAUGE

Dawe Instruments, Limited, 99 Uxbridge-road, Ealing, London, W.5, were showing a new version of their ultrasonic thickness gauge for metals which can be used when only one side is accessible. The first model was described in ENGINEERING, vol. 175, page 808 (1953). The new design extends the range of thickness of steel which can be measured down to 0·02 in. by using higher frequencies than the original model (up to 6 megacycles); the upper limit of thickness remains at 12 in. It is intended primarily for thin materials with smooth surfaces, the original model being recommended for thicknesses greater than 0·25 in.

The same firm were also showing a prototype of their electronic gauge which is fundamentally an accurate length-comparator. The electronic circuit consists of a differential transformer-type gauge-head together with a high-gain amplifier and indicating meter. Any movement of the probe in the gauge-head produces a proportional output signal. The instrument is set up against a standard gauge block, as in the usual comparator, and variations in the parts being gauged are indicated on the meter; for rapid sorting, "high," "pass" and "low" indicating lamps can be used. Four ranges are provided with full-scale deflection corresponding to $\pm$ 0·0001 in., $\pm$ 0·0003 in., $\pm$ 0·001 in. and $\pm$ 0·003 in. Response is rapid and the equipment is adaptable for automatic gauging.

HAND STROBOSCOPE

Also exhibited by Dawe Instruments, Limited, was a simple mechanical stroboscope, the "Strobospot." The unit consists of a mechanically-driven shutter through which the rotating mechanism is viewed. Alternatively, a small projection lamp can be used to illuminate the rotating part through the shutter. The instrument has a direct-reading range of 720 to 1,600 r.p.m. and is capable of measuring speeds between 45 and 5,000 r.p.m.

A new version of Dawe's dynamic-balancing equipment has each part made as a separate unit, so that it is adaptable for balancing specially-shaped or vertically-mounted rotors. In many cases it is possible to check the balance of a unit mounted in its own bearings. The earlier instrument was restricted to cylindrical rotors which having a spindle at each end, and balancing was in the horizontal plane only. Unbalance forces generate electrical signals which are amplified and operate a moving-coil meter. The amplified signal also triggers a stroboscopic lamp which illuminates the rotor, showing the angular location at which the correction must be applied.

Chance Brothers, Limited, Smethwick, Birmingham, were showing special types of glass for absorption and transmission. One of these, a lead-glass, is suitable for observation windows where protection from short-wave radiation is required; another, of the boric-oxide type, can be used for absorbing neutrons; while there is a series containing rare-earth elements which give improved visual and ultra-violet transmissions.

W. G. Pye and Company, Limited, Granta Works, Cambridge, included on their stand a demonstration of how a *p*H meter can be used as an insulation tester. This makes use of the principle that if a known voltage is applied to an unknown high resistance in series with a standard resistance, then the voltage appearing across the standard resistance will be inversely proportional to the high resistance. The demonstration showed one of the firm's *p*H meters being used in this way with a scale directly calibrated in insulation resistance; the full scale value is 10^{12} ohms and a resistance of 10^{15} ohms can be detected.

A microscope exhibited by Taylor, Taylor and Hobson, Limited, Stoughton-street, Leicester, is designed for inspecting the leading and trailing edges of turbine blades. It can be used in full daylight and the eyepiece has clearance for spectacles. Any part of the edge can be viewed to within $\frac{1}{4}$ in. of the root or shroud; the maximum blade width is $2\frac{1}{2}$ in. but the length is not limited. The field of view is 0·18 in. in diameter with a magnification of 40 diameters. A narrow band of light is projected obliquely round the edge of the blade to delineate the section. This viewed obliquely through the microscope so that the image is a normal cross section of the blade. The observed shape is compared with a master drawing, 20 times full size and viewed through an eyepiece which magnifies it twice. The brightness of the drawing image is adjustable for ease of comparison.

ALLOY ANALYSER

The Hilger division of Hilger and Watts, Limited, 98 St. Pancras-way, London, N.W.1, were showing a metal ratio analyser which uses multi-layer interference filters for the analysis. It has been used for the determination of zinc in brass and of magnesium in aluminium alloys and can be adopted for any analysis where high resolution of the spectrum is not necessary. The two channels are direct reading and the accuracy is within $2\frac{1}{2}$ per cent. A more elaborate instrument, which could not be exhibited owing to its size, enables the composition of an alloy, with up to 30 constituents, to be determined in a few minutes. Basically it is a 3-metre concave grating spectrograph with a series of slits arranged in the focal curve to isolate spectral lines. Sensitivity controls allow for line intensities covering a range of 15,000 to 1.

The Watts division of the firm (48 Addington-square, London, S.E.5) were showing a photo-electric comparator for linear scales. Checking against a master scale can be carried out to 1 micro-inch. Also being shown were examples of metallised scales and graticules demonstrating their advantages over etched types. Being actually opaque metal films bonded to the glass, the edges of the lines are clean-cut, without roughness, the filling cannot be lost neither are etching inaccuracies introduced. The scales can be used immersed in liquid, as in manometers and, owing to the clean lines, are particularly suitable for use in magnifying projectors. Alternatively the background can be opaque with clear lines and figures.

One of the items on the stand of the British Thomson-Houston Company, Limited, Rugby, was an electronic clearance monitor which is being developed by their research laboratory. The instrument is intended to measure axial and tip clearances between turbine blade rows and casings. It will operate under running conditions. The principle used is that of the condenser microphone, the change in capacitance as the blades pass a fixed probe being measured. The monitor will also work on the disc supporting the blades as long as some irregularities, such as a number of holes, are provided. Radial or axial clearances in the range 0 to 150 mils can be measured. An alternative use of the monitor is to measure vibration amplitudes from about 10 cycles upwards.

ELECTROLYTIC POLISHER

On the stand of Nash and Thompson, Limited, Oakcroft-road, Tolworth, Surrey, was a ventilation network calculator originally devised at Nottingham University for the National Coal Board. It may be used for any fluid flow problem where the pressure is proportional to some power of the rate of flow. Also on the stand was an electrolytic polisher designed for preparing metallurgical specimens for examination. Heat generated in abrasively polishing the specimen may cause distortion and spreading of the surface layers which, when etched, will fail to give a true picture of the structure. In electrolytic polishing, the specimen is made the anode in a solution specific for the type of metal. The surface which may have become distorted is then removed by electrolysis and a very highly polished surface, revealing the true structure, is left ready for etching. On the front panel of the instrument is the mounting for the electrodes and the stirrer, arranged so that they can be lifted clear of the beaker containing the electrolyte. The working voltage range is from 0 to 70, with a maximum current of 5 amperes. The current is fully smoothed and can be maintained constant; the stirrer has a variable speed control. The specimen may be of any size that will go into the beaker of electrolyte.

CONTINUOUS THICKNESS GAUGE

A gauge for continuously measuring the thickness of strip or sheet material was exhibited by Fielden (Electronics) Limited, Paston-road, Wythenshawe, Manchester. The measuring-head can be mounted at any point over the moving material and can give remote indication of the strip thickness. A lightly sprung wheel runs over the material and is free to move vertically. Attached to it is a vertical rod, moving in guides, in which is fixed an iron core lying within a differential transformer. Vertical movement of the core, caused by variations in thickness of the material, induces a change of voltage in the transformer and this change is used to operate an indicator. The pressure of the wheel on the material can be adjusted and there is a thumbscrew for setting the zero by raising or lowering the transformer relative to the core. The type and shape of pick-up can be selected to suit the material upon which it is to run. If a record is required, then the output voltage can be applied to a recorder instead of an indicator; it can also be used through a servo-mechanism to control the machine. Models are available with an 8-in. circular indicator or with a recorder. The most sensitive have a full-scale deflection representing a thickness change of 0·003 in. and reading down to 0·00001 in.; models are available with ranges up to 0·2 in.

PRODUCTION OF ALUMINIUM WIRE AND CABLE

MECHANICAL HANDLING TO AVOID DAMAGING THE SURFACE OF HOT METAL

In 1946, three companies having extensive interests in aluminium wire and cable production, the British Aluminium Company Limited, Tube Investments Limited, and the Hawker Siddeley Group Limited, undertook jointly the formation of a new concern, the Aluminium Wire and Cable Company Limited. The new company took over a site at Port Tennant, Swansea, which had originally been occupied by a zinc-smelting works, and installed equipment for the production of a wide range of aluminium and aluminium alloy rod, wire and cable for the engineering, aircraft and electrical industries. The rod and wire interests of the parent companies were transferred to the Aluminium Wire and Cable Company Limited.

The Port Tennant works now cover ten acres, and employ about 550 workpeople. There is direct rail access to the adjacent Swansea Docks, and to the main line of British Railways, Western Region. The principal building of the works, which houses the rod-rolling mill, wiredrawing plant and stranding machines, is over 900 ft. long. A nearby site of 60 acres has been acquired to allow for future extensions.

ROD PRODUCTION

The raw material for the works is received in the form of wirebars 4 in. square and 9 ft. long, of the appropriate specification, and is stacked by fork-lift trucks in a storage area at the end of the main building, adjacent to the heating furnaces. Wirebars are lifted from stock as required by fork-lift truck or overhead gantry crane, and deposited on the automatic charging tables of three electric furnaces. These furnaces, which each have a capacity of two tons per hour, were built by the Electric Resistance Furnace Company, Limited. They are of the chain-conveyor, forced air-circulation type (Lindberg system), and operate on 420-volt 3-phase current, the electrical loading being 620 kW. Automatic temperature and overload control is provided by equipment manufactured by the Foster Instrument Company, Limited. The wirebars are heated to 400 deg. C. in their passage through the furnace, and on arrival at the discharge end are ready for rolling.

At the rear end of the furnaces there are extractors which lift the wirebars from the furnace conveyors and deposit them on a live-roller track leading to the roughing mill. Control of the extractors and furnace conveyors is effected manually from a pulpit which faces the rear of the furnaces. Lifting of the wirebars from the furnace conveyors by mechanical extractors, instead of allowing them to slide down skids as is normal with billet furnaces, is in keeping with the general design of the complete mill. Hot aluminium is easily damaged, and any marking occurring at the bar stage would show up in magnified form in the finished rod, and in the wire drawn from it. Movement of the hot material is, therefore, given particular attention, and frictional contact between moving material and stationary surfaces is avoided at all transfer points by the use of suitable lifting or rolling equipment.

From the roller track leading from the furnaces, the hot wirebars enter the first pass of the roughing mill. This is a 21-in. 3-high mill (Fig. 1), built, as were the other mills in the complete line, by the Brightside Foundry and Engineering Company, Limited. It is of orthodox pattern, but the entire manipulation of the bars, which are given seven passes, is by means of mechanical elevating trays and pushers, operated by compressed air and controlled from a pulpit overlooking the mill. Soluble oil is used on this mill and the others in the line as a coolant and rolling lubricant. The roughing mill drive, made by the English Electric Company, Limited, who were responsible for the complete electrical equipment of the rod mill line, is a 500-h.p. motor, taking current at 6,600 volts and running at 740 r.p.m. It is geared to give an average rolling speed at the mill of 650 ft. per minute.

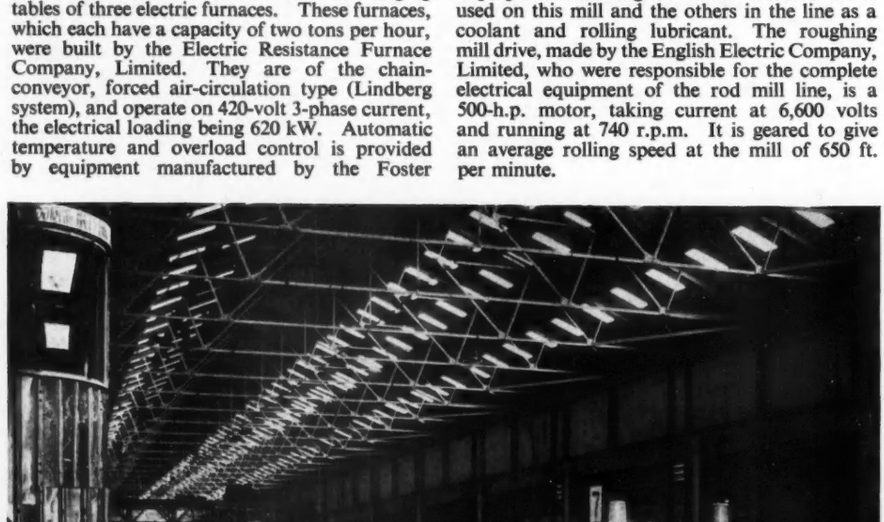


Fig. 2 The delivery end of the continuous finishing mill. When changing from one pass to another the same pass line is retained, the roll stands being "inched" over as required.

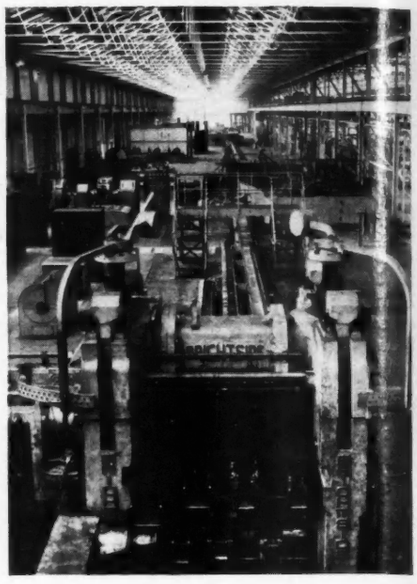


Fig. 1 The roughing stand of the rod rolling mill. The looping stand and the finishing stands are in the background.

The product of the 3-high mill is an oval of 2 sq. in. cross-section. It passes via a live-roller track to the second mill in the line, which consists of two stands of 16 in. rolls installed side by side, and operated in tandem as a looping mill. There are five passes at this pair of stands. The looping mill is driven by an English Electric motor of the same size and speed as that used for the roughing train, and is controlled from the same pulpit.

CONTINUOUS FINISHING MILL

From the looping mill the product passes to a run-out table, at the ends of which are situated air-operated crocodile shears, which crop the ends of the bar before it passes to the finishing train. The bar is then discharged sideways to a live-roller track, turning through 90 deg. as it moves, and enters the finishing train, which has seven stands of rolls. One pass is made in each stand, the stands being set in tandem so that the finishing mill is of the continuous type. A feature of this mill is that alternate stands are arranged with the rolls horizontal and vertical, so that twisting of the bar between passes, with the possible damage to the surface which might occur, is eliminated. There are four stands with horizontal rolls, the first and final ones being of this type, and three stands with vertical rolls. The rolls, which are of indefinite-chill cast iron, range from 15 in. at the entry stand to 10¾ in. at the delivery end. Delivery is at a speed of 3,000 ft. per minute, the output being 6 tons per hour. Control of this finishing train is from a pulpit which overlooks the mill; it is visible on the left-hand side of Fig. 2, which also shows the arrangement of the stands. The controls for two rod coilers, which are placed in tandem with the mill, are also in this pulpit. The mill drive consists of seven motors, each of 150 h.p., with current at 440 volts, the first six being geared to provide the necessary speed increase from stand to stand, and the seventh driving direct. The motors driving the horizontal rolls are mounted at floor level, and connected to the pinion boxes by gear trains, horizontal shafts and couplings. Those driving the vertical stands are in pits below floor level, with enclosed bevel drives to the rolls.

The mill is designed to roll rounds of $\frac{3}{8}$ in., $\frac{7}{16}$ in., or $\frac{1}{2}$ in. diameter, and the rolls are turned with more than one pass of each size in the barrels. The change from one size to another, or to a different pass of the same size, can thus be effected without changing the rolls. An unusual feature of the mill is that in changing from one

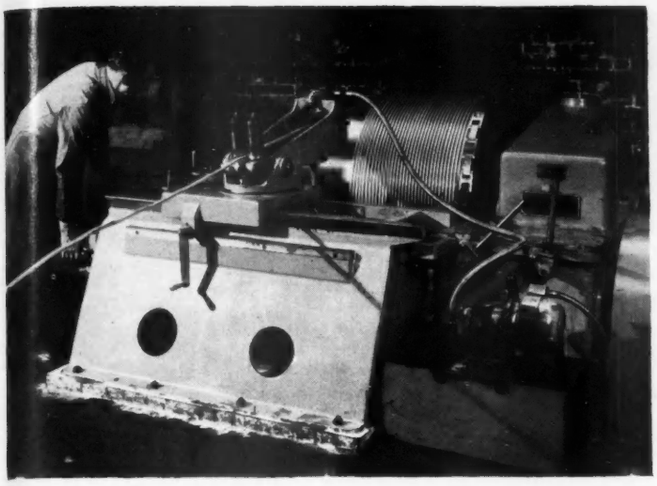


Fig. 3 Heavy-duty single-die machine for producing drawn "wire" between ⅛ in. and 1 in. diameter. This aluminium-alloy wire is used for rivets, etc.

pass to another the same pass line is retained, and the roll stands, complete with their pinion boxes, are moved to meet the guides. The drive to each stand incorporates a telescopic coupling, which enables the stand, complete with its pinion box, to be moved as required. The movement of the stands is motorised, and it is only necessary to slacken the holding-down bolts to enable the stands to be "inched" over. A Brightside roll-turning lathe is provided for roll maintenance.

From the finishing pass in the continuous mill, the rolled rod is led by tubular guides to one of two Brightside rod coilers, which operate at the delivery speed of the mill. The coils are ejected downwards, and pushed sideways by compressed air on to a slat conveyor, which delivers them to an overhead pendulum-type conveyor for inspection and weighing.

WIREDRAWING

The coils of rolled rod are the raw material for a large range of wiredrawing machines, most of which are products of the Marshall Richards Machine Company, Limited. Machines by other manufacturers, including W. H. A. Robertson and Company, Limited, and Sir James Farmer Norton and Company, Limited, are also installed. In this section of the works, wire is drawn in all grades of pure aluminium, and in a range of alloys, to tempers according to requirements. The sizes range from ⅜ in. diameter to 30 s.w.g. (0·0052 in. diameter), in coils or on reels according to the size. Wire between 16 s.w.g. (0·064 in. diameter) and ⅜ or ½ in. diameter is also supplied in straight lengths, and rivet stock is also made up to 1 in. diameter in coils, or up to ½ in. in straight lengths. In addition to ordinary round wire, flattened wire or strip is made up to ¾ in. wide, and square, hexagonal, rectangular, triangular and special sections are drawn as required.

There are a few single-die bull-blocks for the production of larger sizes of strong alloy wire, or for breaking-down purposes, and two specially-designed heavy-duty machines (Fig. 3), for large-diameter rivet or other stock in alloy up to 1 in. diameter. Some two-die machines are also used for breaking-down, and for producing finished wire over ¼ in. diameter. The remainder of the machines are of the multi-die pattern of both slip and non-slip type, with 3, 5, 7, 9 or 11 dies. A typical 11-die machine is shown in Fig. 4. The drawing speeds of these machines range from 1,000 to 3,000 ft. per minute, and the finished wire can be taken up on special reels suitable for use on stranding machines, or as coils. A number of fine-wire machines produce wire from 20 s.w.g. (0·036 in. diameter) down to 39 s.w.g. (0·0052 in. diameter), and these can operate at speeds up to 4,000 ft. per minute. Wire down to 0·010 in. diameter is wound in coils or on reels as required, while below that size it is available on reels only.

The dies used are of tungsten-carbide, except in the case of the finer wires, where diamonds are essential. A fully-equipped die-maintenance department with a range of machines and instruments for servicing and inspecting dies is provided.

For the heat-treatment of wire during or after drawing, there are four 140-kW G.W.B. electric furnaces, complete with a ground-type electric charger, located near to the drawing machines. The furnaces are capable of working up to a maximum heat of 600 deg. C., and the control is automatic, the accuracy obtainable being ± 2½ deg. C. They are charged with coils of wire carried in skips 10 ft. 9 in. long, 4 ft. 6 in. wide, and 3 ft. 4 in. high. A large water-bosh is provided for quenching purposes, and, since quick quenching is essential in heat treatment of alloys, provision has been made for a quench to be completed in 15 seconds.

CABLE PRODUCTION

Adjacent to the wiredrawing section of the works are the cable-stranding machines. Here, stranded conductor cables of various types are made. The stranding machines, which are of the tubular and planetary types, are mostly products of the Trafalgar Engineering Company, Limited. High-speed stranding of steel cores and the manufacture of the smaller sizes of aluminium conductors are carried out on the tubular machines, while the planetary machines are used for the larger conductors. The usual construction of conductor cables is 3, 7, 19, 37, or 61 strand, but odd constructions are made as occasion demands. The Company have manufactured a large proportion of the conductor used in the British 275-kV super-grid; this is a 61/0·125 in. stranded cable, containing 54 aluminium and seven steel wires. A 169/0·146 in. all-aluminium cable has been made experimentally.

Among the other products made at Port Tennant are narrow strip or tape, electrode wire, and straight lengths of wire of various sizes and specifications. The strip is made by flattening wire in small rolling mills, of the single-stand or the tandem type. The larger sizes are dealt with by a Robertson-Tormanco mill with 9 in. rolls, operating at approximately 200 ft. per minute. The smaller mills, which run at 350 to 400 ft. per minute, have provision for layer-winding in coils for such specialised applications as Zip fastener manufacture.

Straight lengths of wire, which are required for a variety of purposes, such as knitting needle manufacture, and machining by various methods, are produced on a battery of Thompson and Munroe straightening machines, which deal with sizes from 0·048 in. diameter to ¼ in. diameter. Larger diameters, up to ½ in., are straightened on a Barron and Crowther heavy-duty machine. Straight lengths up to 16 ft. can be produced in all diameters. Another product which passes through the straightening machines is specially-treated wire made for the consumable-electrode shielded-arc welding process. This product, which has been developed in co-operation with the British Oxygen Company, Limited, has passed the experimental stage, and is being made in increasing quantities. Special care is necessary in all stages of the wire production, to ensure that it has absolute uniformity of chemical and physical characteristics.

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EMBOSSED ALUMINIUM SHEET

Scratches Less Visible and Glare Reduced

An embossed aluminium sheet has recently been added to the range of products made by the British Aluminium Company, Limited, Norfolk House, St. James's-square, London, S.W.1, and tests have shown that this finish has a number of practical advantages over the normal bright-rolled finish. It is less apt to show scratches, dents or other marks arising from rough usage and is therefore particularly suitable for kick plates, skirtings and surrounds, etc. The embossed surface also breaks up light reflections and reduces glare.

The embossing operation work-hardens the metal and by increasing the overall thickness of the sheet has a considerable stiffening effect. The sheet is made with two patterns, light stucco and heavy stucco; the distinction between the two is in the depth of the impression. Both patterns are made in sheet of 99 per cent. commercial purity and B.A. 60 alloy, in gauges from 24 to 16, and in soft and half-hard tempers.

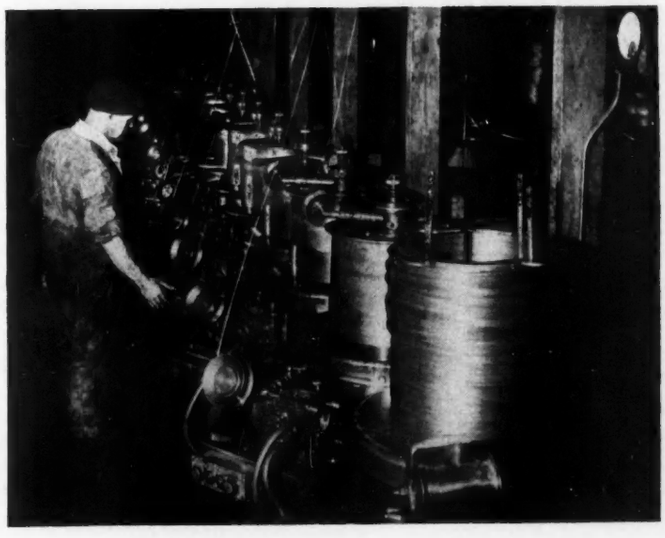
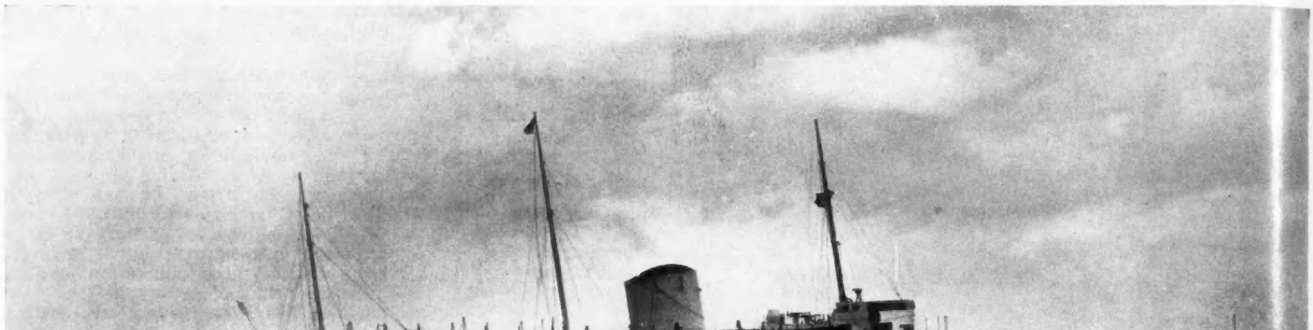


Fig. 4 Continuous wire-drawing machine with eleven dies.



HER MAJESTY'S YACHT "BRITANNIA" *

By Sir Victor Shepheard, K.C.B., R.C.N.C.

This paper is presented to the Institution of Naval Architects with the gracious permission of Her Majesty the Queen. On April 16, 1953, Her Majesty launched the new Royal Yacht Britannia at the Clydebank shipyard of Messrs. John Brown and Company (Clydebank), Limited.

DESIGN

In 1938, the Admiralty considered the possibility of building a ship which would not only replace the Victoria and Albert but which could be economically converted to a hospital ship in the event of war. With the advent of war, however, the matter was dropped.

In 1951 the project was revived and sketch designs were started in the Admiralty on the basis of the 1939 design, reduced in size. It was decided that the ship should be suitable for service in both tropical and arctic waters. A continuous sea-going speed of 21 knots was required, and an endurance of at least 2,000 miles at 20 knots at load displacement.

The necessity for economy in the cost of construction was kept continually in mind during the design and construction of the ship. The late King and subsequently Her Majesty the Queen both stressed this need for economy and made many suggestions with the object of reducing expenditure. Even after the design had been commenced the original requirements were reviewed and many changes were made to reduce the size of the ship. It was necessary, however, that the size was not so reduced as to impair her seaworthiness when undertaking long ocean passages. Moreover, the ship had to be large enough to permit of economical employment as a hospital ship in war time. It was decided that the smallest ship to meet these requirements was one of about 4,000 tons displacement.

Designs had to be developed simultaneously for the Royal Yacht and hospital ship rôles and the best arrangement worked out to meet both requirements, at the same time ensuring that the work and cost of conversion in war time would be kept to a minimum. For example, certain features have been embodied in the design which add to the value of the ship as a Royal Yacht, but which are not altogether essential for that purpose. They would, however, be necessary if and when the ship is used as a hospital ship. Such features include stabilisers, certain air-conditioning, large laundry facilities and comparatively high speed, none of which could be added on conversion as a hospital ship except at considerable additional expense and long delay in completion. As a Royal Yacht the ship will wear the White Ensign and be manned by a naval crew. As a hospital ship she would be manned by a merchant service crew and wear the Red Ensign.

A photograph of the Britannia on trials is shown above. She has a modern appearance, with clipper bow and modified cruiser stern. Three masts are a requirement for a Royal Yacht; the Royal Standard is worn at the main, the Flag of the Lord High Admiral at the fore, and the Union Flag at the mizen. It was obvious that the Royal and State apartments and accommodation for the Household and Royal staff should be aft, with the ship's company forward.

The order was placed with John Brown and Company (Clydebank), Limited, in February, 1952. The keel was laid on June 16, 1952, the vessel was launched on April 16, 1953, and was completed and accepted by the Admiralty on January 11, 1954.

PRINCIPAL DIMENSIONS

The principal dimensions and other leading particulars of Britannia are given below.

Length overall	412 ft. 3 in.
Length on waterline	380 ft. 0 in.
Length between perpendiculars	360 ft. 0 in.
Maximum breadth moulded	55 ft. 0 in.
Breadth at upper deck moulded	54 ft. 6 in.
Depth moulded to upper deck 45 ft. abaft amidships	32 ft. 6 in.
Depth moulded to upper deck at fore perpendicular	40 ft. 4 in.
Depth moulded to upper deck at after perpendicular	33 ft. 10 in.
Load displacement	4,715 tons
Mean draught at load displacement	15 ft. 7½ in.
Gross tonnage	5,769 tons
Shaft horse-power	12,000
Speed on trials at 12,000 shaft horse-power (at 4,320 tons displacement)	22·75 knots
Corresponding r.p.m.	286
Continuous sea-going speed	21 knots

In the load condition the ship carries 330 tons of oil fuel, which is more than sufficient to obtain the design endurance of 2,000 miles at 20 knots; and 120 tons of fresh water, which is considered sufficient for two days' supply without evaporators working. Extra tank capacity is available for use on long ocean passages, and by its use the oil fuel capacity can be increased to 490 tons and the fresh water to 195 tons.

SHIP MODEL EXPERIMENTS

Arrangements were made for investigations and model experiments to determine the best form of hull to meet the requirements both in calm waters and rough seas. Calculations and experiments were also made to determine the most suitable design of propeller, having regard to propulsive efficiency and the avoidance of cavitation, erosion, and vibration. Wind-tunnel tests were carried out to ensure that the bridges would be as free from draughts as possible, and to obtain a satisfactory design of funnel. These wind-tunnel tests were conducted by the Aerodynamics Division of the National Physical Laboratory, Teddington.

The first experiments to determine the resistance of the hull were carried out by Messrs. John Brown, who ran a model in their tank at Clydebank at a displacement corresponding to 4,470 tons, level trim, over a speed range from 14 to 22 knots. Afterwards the Admiralty Experiment Works, Haslar, ran a model to slightly different displacement and draught and compared the results with those of other good hulls of about the same proportions and speed, including methodical series results. They confirmed that the hull lines were of a very good standard throughout the speed range. Messrs. John Brown then proposed a semi-bulbous bow as showing an improvement in performance above 18 knots, although performance was slightly prejudiced below that speed. The form was modified to include a semi-bulbous bow, the lines were slightly fined forward and filled out aft, and all cut-up forward was deleted. The final model was run by Messrs. John Brown with satisfactory results.

Before deciding on the propeller design, calculations were made at Haslar of the natural frequency of vertical flexural vibration of the hull for guidance in determining the number of blades to avoid propeller excitation. It was deduced that three-bladed propellers might stimulate resonance, due to shaft excitation superposed on blade excitation, over a speed range of 16½ to 19 knots. Resonance due to shaft excitation with four-bladed propellers might be excited from 16 to 18 knots and with blade excitation from 14 to 15 knots. Experience on comparable ships suggested that transverse hull vibration might also be excited over the speed range quoted above for three-bladed

* Paper read at the Spring Meeting of the Institution of Naval Architects, held in London on April 7 to 9, 1954. Abridged. The discussion on the paper is reported on page 522.

propellers, but only at lower speeds for four-bladed propellers. On the whole, the risk of objectionable vibration was regarded as slight with four-bladed propellers, whereas objectionable vibration might be induced with three-bladed propellers due to a combination of nodes and frequencies. It was therefore decided to fit four-bladed propellers.

Advance calculations indicated that the critical speeds of axial shaft vibration both for three-bladed and four-bladed propellers were greater than the maximum shaft revolutions per minute. The margin for four-bladed propellers was rather small, but this was regarded as less serious than the risk of general hull vibration if three-bladed propellers were fitted. Haslar worked out proposed particulars for a four-bladed propeller and Messrs. John Brown prepared the detailed design with the following characteristics:

Diameter	10·25 ft.
Pitch	9 ft.
Developed blade area	55·7 sq. ft.

A model propeller of 12 in. diameter, made in manganese bronze, was tested at Haslar over a range of cavitation number from 6·55 to 1·7, corresponding to a range of nominal ship speed from 13·4 to 26·3 knots. Cavitation was light and restricted to a small zone of sheet cavitation on the back of each blade towards the tip, and slight face cavitation near the leading edge in the region of 0·5 to 0·8 radius. The latter was avoided by slight washback.

RUDDER

Very careful consideration was given to the turning qualities of the design. Torque and normal force on the rudder were determined from measurements on a propelled model hull when on a straight course with the rudder adjusted in turn to various angles. The maximum rudder torque was estimated to be 125 tons-ft. at 14 knots astern and 30½ deg. angle. The torque was reduced to 116 tons-ft. at 35 deg. angle, but was larger at greater angles outside the operating range. When proceeding at 22 knots ahead the torque was 69 tons-ft. and at 15 knots was 33 tons-ft., both at full rudder angle of 35 deg. The maximum normal rudder force was estimated to be 63·5 tons at 22 knots ahead, and 25·5 tons at 14 knots astern. The centre of pressure was abaft the rudder axis at all forward speeds and for all rudder angles tested. The results indicated a comparatively small discontinuity in the progressive increase of torque and force with angle in ahead motion at about 30 to 35 deg. and a definite stalling at 30½ deg. in astern motion.

SEAWORTHINESS

Comprehensive experiments were carried out at Haslar to investigate the sea-keeping qualities of the ship. A model to a scale of 1/32nd full size was tested head-on to uniform waves when towed at speeds corresponding to 10, 15, and 20 knots and in following waves of speeds corresponding to 10 and 20 knots. Tests were also made with the model hove-to, head on to the waves. The wave lengths ranged from 200 to 700 ft. at full scale with heights 1/20th and 1/40th the length. The motion in ahead seas was heavy in long waves, but was reduced in short waves, the motion being small when the length of the wave was less than about three-quarters the length of the ship. Generally, peak oscillations occurred in waves about 30 per cent. or so longer than the ship and were more severe at high speed. The maximum amplitude of pitch was about 20 deg. (out to out) and of heave 32 ft. (out to out) at 20 knots in waves about 500 ft. long. Over the speed range up to 20 knots the peak of hull resistance occurs in waves which are shorter than those causing peak motions. The maximum speed that can be sustained at sea with full power was deduced to be about 20 knots in waves 4 ft. high, reducing to about 10 knots in waves 20 ft. high.

The experiments verified that the design had good sea-keeping qualities except that, in waves 400 ft. long and 20 ft. high, green seas were taken over the bow at all speeds. The water flowed rapidly aft when the model pitched with stern down, crashed against the front of the bridge and was deflected overboard through the freeing doors in the bulwarks at the after end of the forecastle. Heavy spray was thrown over the bridge. The height of the bulwark at the bow was increased from 4 ft. to 6 ft., a modification which caused conditions to improve considerably. In fact, with the ship trimmed 2 ft. by the stern no water at all was taken over the bow in any condition of speed of model and size of wave investigated.

CONSTRUCTION

All the structural plans were submitted to Lloyd's Register of Shipping as is the practice for classed merchant ships, and in the final form these plans were approved by both Lloyd's Register and the Admiralty. The vessel has been surveyed during construction by Lloyd's surveyors in conjunction with Admiralty Overseers. The profile is shown below.

The upper, main, and lower decks are worked continuously over the entire length of the vessel except in way of boiler-room uptakes. The platform deck is watertight throughout, watertight hatch covers being fitted for access. Main watertight transverse bulkheads are carried to the upper deck. There are no openings in these bulkheads below the lower deck. The usual water-tight door access between machinery spaces and shaft tunnels in merchant ships is omitted, naval practice being followed in this respect. Electrically operated horizontal sliding watertight doors are fitted to the watertight bulkheads on the lower deck. They can be power-operated locally or from the bridge, or hand-operated locally or from the main deck. Three of the main transverse bulkheads are fire-resisting.

The ship is transversely framed, the frame spacing being 2 ft. Deep web frames are fitted at intervals in the machinery spaces and also at intervals aft from 153 bulkhead to the stern. The structure is particularly strong in way of the shaft bossings, which have been adopted at the request of the shipbuilders in preference to the Admiralty practice of fitting shaft brackets. In the State rooms on the upper deck aft, deep web frames and beams have been used to obviate the need for pillars.

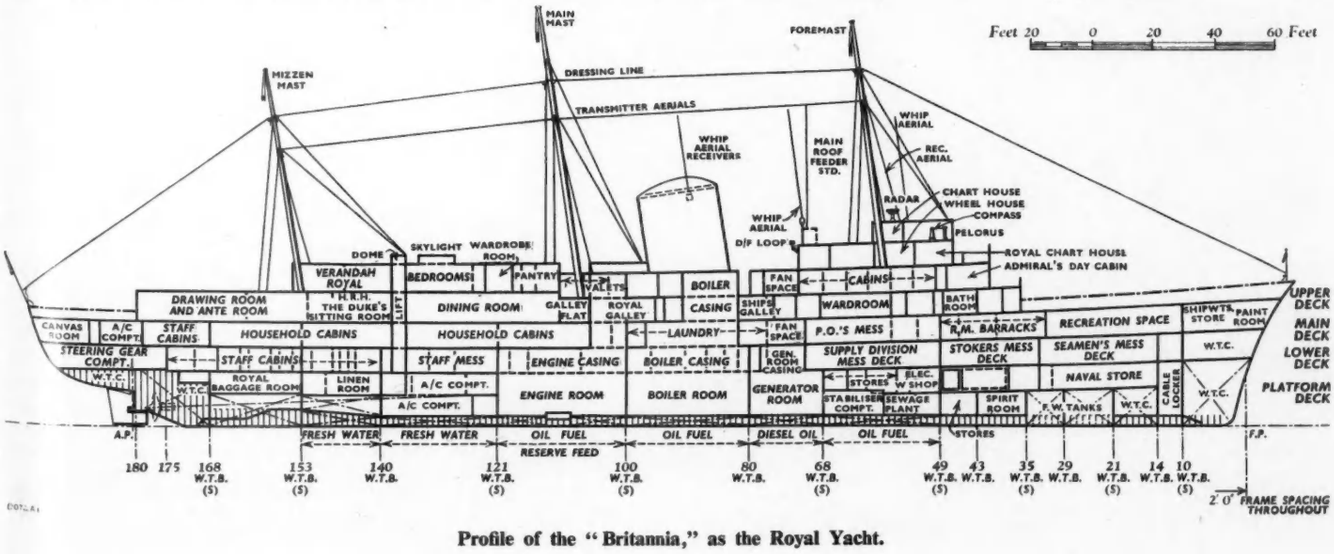
The shell plating above the light waterline is worked flush. Below the waterline the plating is lapped, but the plate edges forward have been faired with composition. Butts of shell plating below the waterline and the shell plating in way of reserve feed tanks and fresh-water tanks are welded. The internal boundaries of oil-fuel tanks are also welded.

Light alloys have been used to a limited extent. It was originally intended that all the superstructures should be of aluminium alloy, but it was later decided to use steel because of the high cost of aluminium. Aluminium has, however, been retained for the superstructure above the bridge deck and for the funnel. All decks except the platform have a camber of 9 in. on the full moulded breadth. A minimum 'tween-deck height of 8 ft. has been adopted except in a few places; it is 10 ft. throughout the State apartments. The after end of the sun deck has been stiffened so that it can be used, if required, as a helicopter landing deck.

All weather decks are sheathed with 2-in. teak. The upper deck is protected all round by bulwarks 3 ft. 6 in. deep amidships, rising to 6 ft. high at the bow. Freeing-port area, in excess of the requirements of the Load Line Rules, is provided in the form of bulwark doors, which are kept open at sea. These doors will normally be closed in protected waters to preserve the unbroken appearance of the bulwarks. Steel screen doors are provided for use in bad weather to protect the large wooden entrance doors to the State apartments on the upper deck. Portable metal screens are provided for all the large glass windows aft on this deck.

To reduce possible heel if damaged, no longitudinal watertight bulkheads other than normal tank boundaries have been fitted. To meet the requirement of the Merchant Shipping (Construction) Rules 1952 that, in the event of unsymmetric flooding the resulting, heel is not to exceed 7 deg., the shaft tunnels have been cross-connected, as also have been the large wing oil-fuel tanks aft.

To be continued



Profile of the "Britannia," as the Royal Yacht.

6-IN. COPY-TURNING LATHE

SHORT SETTING-UP TIMES FOR BATCH PRODUCTION

Alfred Herbert, Limited, Coventry, have recently introduced a copy-turning lathe embodying some new features. Known as the "Carbitracer," it will turn shafts up to 6 in. in diameter and 48 in. long using either a template or a master shaft. The main saddle and the copying mechanism are arranged to be above the workpiece, and therefore are not fouled by falling chips and swarf. As there is only a single tool which needs adjusting for work diameter, setting-up time is short; the only other alterations are to traverse the master or template and to adjust the length stop. Less than an hour is needed for a change-over, so the machine can be used economically for small-batch production.

Fig. 1 is a front view of the machine. All the electrical control gear is contained in the cabinet on the right, where are push-buttons controlling the blower motor and the hydraulic pumping unit. The former is for cooling the main driving motor, permitting the frequent starting and stopping required on short time-cycle operations. Electrical interlocking prevents the driving motor being started if the blower is not running. The driving motor is rated at 20 h.p. and the lathe has been made sufficiently rigid for the whole power to be utilised. The rigidity also allows a good finish to be obtained, reducing the amount of grinding and polishing needed afterwards.

The driving and blower motors are housed in the left-hand cabinet, which constitutes the headstock of the machine, and above them is the gearbox. Four sliding gears give speeds of 410, 530, 1,160 and 1,500 r.p.m.; each of these may be reduced, by engaging a friction clutch, in the ratio of 1·67 to 1. This gives a full speed range from 250 to 1,500 r.p.m. Push buttons on the headstock provide control for starting, stopping and inching. Quick stopping of the spindle is ensured by a plugging relay which is also operated by a push button. Lubrication is by oil which is continuously filtered.

The bed slideways carry the saddle, which, with its hydraulic mechanism, is shown in Fig. 2, and also the master tailstocks and template fixings. A master shaft can be seen behind the saddle in Fig. 1. The workpiece is on the front of the lathe and swarf from it falls directly into the large bin below. This is mounted on castors for easy removal. As the hot chips do not fall on the machine the temperature is kept down, and distortion during machining is less likely. This also means that a high rate of metal removal is possible.

QUICK TRAVERSE

The saddle has three rates of automatic feed, giving 60, 80 and 120 cuts per inch. Selection is by a lever on the headstock. There is a safety slipping clutch on the drive and also the Herbert "Chiprupter" mechanism which enables the feed to be momentarily stopped for the purpose of breaking long turnings into safe lengths. This mechanism can be operated from either the headstock or the controlled position. The automatic feed is towards the headstock only and is engaged by a lever on the saddle. An adjustable collar trips the lever at the end of the cut. For reducing non-cutting time there is a quick power traverse and interlocked with this there is a hand traverse for setting up.

On an inclined tool slide is mounted the hydraulic cylinder and the Metrovick profiling mechanism. There is rapid traverse in both directions. The tool post has a vertical adjustment with a graduated dial recording to 0·001 in. A stop on the inclined slide to limit the downward travel can be adjusted by the fluted knob visible in Fig. 2; the divisions on the graduated dial represent 0·002 in. of vertical movement. The inclined slide returns to the fully-up position on the rapid reverse movement of the saddle.

SQUARE SHOULDERS

The tracer is tipped with Ardoloy to reduce wear and will give a sensitive response even when traversed up to a square shoulder. A manually-operated valve permits the tool to be withdrawn from the workpiece whenever it is required. As an inclined slide is used, the mechanism can copy square shoulders. The hydraulic pumping unit is mounted at the rear of the machine so that all flexible pipes are safe from damage by chips and swarf.

Fig. 1 A front view of the copy-turning lathe; chips from the workpiece fall directly into the bin. The master is mounted above the slides.

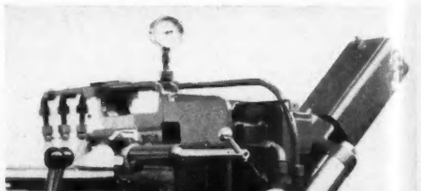


Fig. 2 The inclined tool slide carries the Metrovick hydraulic profiling mechanism. Heavy cuts can be made and square shoulders copied.

The two forming or recessing slides, whose control handles can be seen in Fig. 1, can be positioned and locked on the same V-slideway as the work tailstock. Each slide carries a tool-post and is fitted with an adjustable stop. A graduated dial shows the depth of cut. The sleeve of the main tailstock carrying the running centre is hydraulically controlled. The hydraulic pressure allows for work expansion and a non-return valve prevents fall of pressure in the cylinder should the line pressure fail. The lathe is fitted with sliding guards having Triplex windows and also with V-rests for supporting the work during loading.

Masters can be used for all copy turning up to 4 in. in diameter; above this, templates are required. Masters may be smaller in diameter than the actual workpiece – an advantage for storing and handling, especially when large workpieces are being machined.

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CORROSION-PROOF MOTORS

The English Electric Company, Limited, Kingsway, London, W.C.2, are now manufacturing a range of motors which have been designed for use in corrosive, but non-explosive, atmospheres. They are particularly intended for employment in chemical plants, plating shops, gas works, salt works and oil refineries. They are manufactured to British Standard dimensions and are available in outputs up to 25 h.p.

A special feature is that wherever possible cast iron is used for the external surfaces. The stator winding is insulated with polyvinyl-acetal and is impregnated with phenolic insulating varnish by dipping and baking four times in an automatic heat-controlled oven.

Cooling is effected by a fan, which is mounted on the non-driving end of the shaft and blows air along axial cooling fins, which are cast integral with the frame. This fan is made of phenol formaldehyde, a material which has been shown to be suitable for the purpose by repeated durability and fatigue tests. The cowl over the fan is of cast iron, instead of pressed steel.

Labour Notes

RECRUITS FOR ENGINEERING

References to the shortage of students entering the field of engineering were made by Sir George E. Bailey, M.I.Mech.E., M.I.E.E., the chairman of Associated Electrical Industries Limited, in his address to stockholders at the company's annual meeting on March 31. Sir George said that this was a matter which had an important bearing on the future of the company and of the industry as a whole.

The shortage had caused the management of the company concern for some time and they had reason to believe that it was connected, to some extent, with the shortage of science masters at schools. They were glad to notice, however, that there had developed lately an increasing awareness of the problem.

A satisfactory solution of the difficulty, Sir George emphasised, was vital to the well-being of the industry, as only by recruiting sufficient personnel of the right types could British industry maintain its position in the forefront of the world's markets.

FOREIGN COMPETITION

Turning to the future prospects of the industry, Sir George said that attention could not be drawn too often to the fact that the desperate measures being taken by foreign competitors, together with the rising prices in Britain, had made it essential that efforts should be redoubled to reduce the costs of this country's products in every direction.

It was not sufficiently appreciated that, since the war ended, Britain had moved from the position of having no competition from German and Japanese manufacturers to one where these nations were rapidly increasing their engineering exports. Most factories in Germany and Japan had been rebuilt on modern lines and fitted out with first-class tools and equipment.

Referring to the negotiations which were then proceeding on wage rates in the engineering industry, Sir George expressed the hope that, whatever the outcome, they would result in a lengthy period of wage stability. There had been no stability in this connection since before the war and such a condition was indispensable to any industry, particularly at a time of growing competition.

The basic strength of the company and its subsidiaries, Sir George pointed out, lay in the wide range of equipment they manufactured. Their products found application through almost the whole range of human activity. The growth of the demand for electrical energy, both in Britain and throughout the world, continued at a steady rate and assured the companies of an increasing market, which, provided it were possible to maintain competitive prices backed by an aggressive selling organisation, should secure an adequate flow of orders sufficient to keep their expanding plants in full employment.

LORD HIVES ON MANAGEMENT

Persons engaged in industry, Lord Hives, C.H., stated recently, were never short of advice on management and it was astonishing how many people could tell them how to do their job. Nevertheless, he said, he had been forced to the conclusion that such people could make no real contribution to management problems. There were subtle qualifications for successful management which were difficult to define. Final decisions had to be based on a balanced judgment, taking into account a number of factors, many of which were peculiar to a particular business or firm.

Lord Hives, who is chairman and joint managing director of Messrs. Rolls-Royce Limited, and was addressing members of the Gauge and Tools Makers' Association at a luncheon in London, considered that the difficulties of management at the present time were not being eased by the attitude of what might be described as the " big battalions."

Trade unions, measured by the number of members they controlled, were getting larger. Opposite to them was the employers' Federation, which also did everything it could to increase its membership. The Press made headlines of any differences which might exist between the unions and the workpeople and the employers. In addition, there were radio and television. But, in spite of everything, management had to adapt itself and operate efficiently.

DIVIDED LOYALTIES

The impression which might be obtained, Lord Hives continued, from the publicity that ensued was that every improvement in the workers' conditions had to be wrung out of industry by the unions, which was entirely wrong. Thousands of increases were being given to employees, all the time, which had nothing to do with the unions. Enlightened employers were always seeking to improve the pay and conditions of their workpeople.

Under the rule of the " big battalions," an employer who had created the best possible conditions in the factory he operated, and the average earnings of whose workpeople were higher than some new wage increase which might be under negotiation, received no greater consideration than any other employer. If an increase were granted, it was expected that the differential rates would remain the same.

Should there be a call for a one-day strike, as had happened recently, members of a union followed the instructions of their leaders, as was only to be expected. Such a course, however, had the effect of striking a discordant note in factories where managements and workpeople had been working happily together. It caused numbers of workpeople to be unhappy because their loyalties were divided between their firms and their unions.

TRADE-UNION CONDITIONS IN CANADA

It was interesting, Lord Hives proceeded, to observe the labour and trade-union conditions in force at a factory which his firm had in Canada. In the first place, the unions appeared to sort out some of their difficulties themselves, so that the factory management had to deal with only one union. Further, the union officials with whom agreements were negotiated were representative workers in the factory concerned.

As he understood it, executive officials of the union were only called in if there was a failure to agree. When negotiations were completed, a contract setting out rates of pay and all other conditions of work was signed. This was a legal document, to which penalties for non-compliance were attached, and was settled only after due consideration had been given to the kind of work executed at the factory and the types of workmen employed.

Another factor, about which the unions made no secret, was that if a firm was prosperous and making good profits, they would demand the best possible terms, not only regarding rates of pay, but with respect to such matters as medical services, pensions and paid holidays. On the other hand, if a firm was doing badly and not making profits, it had difficulty in obtaining employees.

The factory had not been working long enough for conclusions to be drawn as to how these arrangements would work out, but it was a considerable satisfaction to know that labour bargains were being made in accordance with the conditions in force at the firm's own factory and not with those applying to factories generally. Factories, that is, which were probably situated at a distance and making an entirely different product.

Earlier, Mr. F. W. Halliwell, the President of the Association, had congratulated the members of the organisation on the progress which had been made during the twelve years of its existence and on the cordial relations which existed between it and Government departments, especially the Ministry of Supply. The Association started with 16 founder-members and now had more than 300 firms on its roll.

RATES OF PAY FOR RAILWAY SALARIED STAFFS

According to a leading article in the April issue of its official *Journal*, the Transport Salaried Staffs' Association has submitted proposals to the British Transport Commission for a new salary structure for its members based on principles approved by the union's annual conference in 1949 and on the salary structure obtaining in the local government service.

The union, it is affirmed, is anxious to proceed with the task of negotiating a sound salary structure such as will provide proper recognition of work performed and responsibilities borne, including those of supervision. The structure must provide adequate differentials as an incentive to employees to seek promotion.

There is no good reason why railway and allied salaries should be tied to the wages of the conciliation grades and it follows, the union states, that discussions on a new salary structure could proceed independently of those relating to railway wages.

FURTHER WAGE INCREASE FOR ELECTRICIANS

The extended dispute in the electrical-contracting industry over wage rates appears to have been settled. An award by the Industrial Disputes Tribunal, announced on April 13, granted adult skilled operatives in the industry an extra half-penny an hour as from March 15.

Following a series of isolated strikes in various parts of the country, spread over a period of two months, an offer of an increase of 2*d.* an hour for skilled grades, equivalent to 7*s.* 4*d.* a week, was accepted by the men's union, the Electrical Trades Union, on March 11. It was agreed that proportionate amounts should be paid to adult mates and apprentices, and that the increases should date from March 15. In all, some 45,000 employees in the industry were expected to benefit.

Normal working was accordingly resumed as from March 12, but it was part of the agreement that there should be an early meeting of the National Joint Council for the Electrical Contracting Industry to consider a further advance in wages. Meetings of the Council were duly held but resulted in a deadlock.

In view of this, the union claimed that the industry's negotiating machinery had been exhausted and asked the Minister of Labour to arrange for the dispute to go to arbitration. The employers' organisation, the National Federated Electrical Association, agreed to this course of action and the two parties presented their cases before the Tribunal on April 5.

When the claim was originally presented about a year ago, the union asked for a " substantial increase," and it was generally understood that advances of 3*d.* an hour for skilled men in the London area, and 2½*d.* an hour for skilled men employed elsewhere, were expected.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

POOLE
Various short papers. Bournemouth Branch. Dolphin Hotel, Poole. Mon., April 26, 8.15 p.m.

British Institution of Radio Engineers

WOLVERHAMPTON
"Radio Telephone Equipment," by T. C. Howell. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Tues., April 27, 7.15 p.m.

Chemical Society

EDINBURGH
"The Story of the *iso*Quinoline Alkaloids," by Dr. R. H. F. Manske. Centenary Lecture. Biochemistry Department, The University of Edinburgh, Teviot-place, Edinburgh. Tues., April 27, 5.30 p.m.
NEWCASTLE-UPON-TYNE
"The Story of the *iso*Quinoline Alkaloids," by Dr. R. H. F. Manske. Centenary Lecture. Newcastle and Durham Branch. King's College, Newcastle-upon-Tyne. Fri., April 30, 5.30 p.m.
ST. ANDREWS
"The Story of the *iso*Quinoline Alkaloids," by Dr. R. H. F. Manske. Centenary Lecture. St. Andrews and Dundee Branch. United College, St. Andrews. Thurs., April 29, 5.15 p.m.
SWANSEA
"Some Reactions of Free Radicals," by Dr. W. A. Noyes, Jun. South Wales Branch. University College, Swansea. Mon., April 26, 6 p.m.

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TUBULAR STEEL ENGINEERING

Post-War Developments Filmed

The rapid progress made both in manufacturing techniques and in the applications of tubular steel, is shown in "The Tubewright," a new film made for Stewarts and Lloyds, Limited.

Tracing the use of the hollow structural member, the film recalls some natural examples, including the corn stalk and the bird's quill, and continues with references to the two outstanding examples of tubular construction of the Nineteenth Century: the bridges over the Menai Straits and the Firth of Forth. The full possibilities of the tube could not be realised, however, until the advent of the modern methods of metallic arc welding. Noting the significant strength-to-weight ratio of tubes, the film shows their successful application as structural members for bridges, crane jibs and materials-handling equipment; their value in the building industry, when prefabrication is adopted, was also recorded in the film as was the use of tubes for cable drums, gates and fencing, as well as for pallets for handling components on production and assembly lines.

"The Tubewright," an Ace Film production, is available for exhibition free of charge and copies can be borrowed through the agents at home and abroad of Stewarts and Lloyds, Limited, Brook House, Upper Brook-street, London, W.1.

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CORE-BALANCE EARTH-LEAKAGE CIRCUIT-BREAKERS

Chilton Electric Products, Limited, Hungerford, Berkshire, have designed a circuit-breaker operating on the core-balance or differential-current principle for the protection of small industrial and domestic installations. It is arranged so that it directly controls the maximum earth fault current and should therefore be useful in dealing with conditions which, although capable of starting a fire, are not necessarily accompanied by an appreciable rise of voltage. Where the earthing conditions are poor, however, it must be used in conjunction with some form of voltage-operated protection, if the risk of shock is to be avoided.

These earth-leakage circuit-breakers are being made for direct-current, single-phase and three-phase circuits of current-carrying capacities up to 60 amperes and voltage ratings up to 550 volts alternating current or 250 volts direct current. Combined voltage-operated and core-balance circuit-breakers can also be supplied for a similar range of ratings. The units are contained in sheet metal cases and may be fitted with earth-leakage and remote tripping attachments and auxiliary alarm contacts.

Incorporated Plant Engineers

BIRMINGHAM
"Welding," by F. A. Thomas. Imperial Hotel, Birmingham. Fri., April 30, 7.30 p.m.
LEEDS
"Fluid Drive in Industrial Application," by E. C. Farrer. West and East Yorkshire Branch. The University, Leeds. Mon., April 26, 7.30 p.m.
LIVERPOOL
Chairman's Address. Merseyside and North Wales Branch. Radiant House, Bold-street, Liverpool. Mon., April 26, 7.15 p.m.
SHEFFIELD
Various short papers by members. Sheffield Branch. Grand Hotel, Sheffield. Thurs., April 29, 7.30 p.m.

Institute of British Foundrymen

LONDON
Annual General Meeting. Film on "Dust Extraction," presented by W. H. White and W. B. Lawrie. Waldorf Hotel, Aldwych, W.C.2. Wed., April 28, 7 p.m.
BIRMINGHAM
Annual General Meeting. "Some Running and Feeding Methods Used for Grey-Iron Castings," by P. A. Russell. James Watt Memorial Institute, Birmingham. Wed., April 28, 7.15 p.m.

Institute of Fuel

LONDON
"The New Education Scheme of the Institute of Fuel," by Dr. D. T. A. Townend. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., April 29, 5.30 p.m.
MANCHESTER
Annual General Meeting. "Energy in the Future," by Dr. J. Bronowski. North-Western Section. Engineers' Club, Manchester. Wed., April 28, 2.30 p.m. (Members' Luncheon, 1 p.m.)
NEWCASTLE-UPON-TYNE
Annual General Meeting. North-Eastern Section. King's College, Newcastle-upon-Tyne. Mon., April 26, 6.30 p.m.

Institute of Marine Engineers

LONDON
"New Metals in Engineering," by Dr. L. B. Pfeil. Tues., April 27, 5.30 p.m.

Institute of Refrigeration

LONDON
"Valve Behaviour and the Performance of Small Compressors," by J. F. T. Maclaren. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Tues., April 27, 5.30 p.m.

Institute of Road Transport Engineers

GLASGOW
Annual General Meeting. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., April 26, 7.30 p.m.

Institution of Civil Engineers

LONDON
James Forrest Lecture on "The Geological Survey of Great Britain," by Dr. W. J. Pugh. Tuesday, April 27, 5.30 p.m.
SHEFFIELD
Annual General Meeting. "Land Drainage in England and Wales," by E. A. G. Johnson. Yorkshire Association. Royal Victoria Station Hotel, Sheffield. Fri., April 30, 7 p.m.

Institution of Electrical Engineers

LONDON
"The Experimental Synthesis of Speech," by W. Lawrence. Radio Section. Mon., April 26, 5.30 p.m.
"Auto-Self-Excited Transductors and Push-Pull Circuit Theory," by A. G. Milnes and T. S. Law; and "Composite Cores for Instrument Transductors," by Dr. E. H. Frost-Smith and A. E. De Barr. Measurements Section. Tues., April 27, 5.30 p.m.
"Aluminium-Sheathed Cables," by P. M. Hollingsworth and P. A. Raine. Supply Section. Wed., April 28, 5.30 p.m.
Kelvin Lecture on "The Physics of the Ionosphere," by J. A. Ratcliffe. Thurs., April 29, 5.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "The Mathematical Content of Engineering Courses." Education Group Meeting. Wed., April 28, 6.45 p.m.
"Nodular Cast Iron: Its Present Position and Future Prospects as an Engineering Material, with Special Reference to Its Suitability for Crankshafts," by S. B. Bailey. Automobile Division and Applied Mechanics Group. Fri., April 30, 5.30 p.m.
BRISTOL
"Brakes for High-Speed Automobiles," by J. A. Channer. Western A.D. Centre. Car Division Offices, Bristol Aeroplane Co., Ltd., Filton, Bristol. Thurs., April 29, 6.45 p.m.
GLASGOW
James Clayton Paper on "A New Frontier: Air-Pollution Control," by Frederick S. Mallette. Scottish Branch. Royal Technical College, George-street, Glasgow. Thurs., April 29, 7.30 p.m.
LINCOLN
"Contemporary Methods of Watch Production," by E. A. Fell and P. Indermuhle. East Midlands Branch. Technical College, Lincoln. Wed., April 28, 7.30 p.m.
MANCHESTER
James Clayton Paper on "A New Frontier: Air-Pollution Control," by Frederick S. Mallette. North-Western Branch. College of Technology, Sackville-street, Manchester. Mon., April 26, 6.45 p.m.
PORTSMOUTH
Repetition of the Address by the Chairman of the Automobile Division: "Combustion in Compression-Ignition Oil Engines," by Professor S. J. Davies. Southern Branch. Anglesey Road Extension, Portsmouth Municipal College, Portsmouth. Thurs., April 29, 7 p.m.

Institution of Production Engineers

LUTON
Film Evening. Town Hall, Luton. Tues., April 27, 7.15 p.m.
MANCHESTER
"Modern Gear Production," by H. J. Watson. College of Technology, Sackville-street, Manchester. Mon., April 26, 7.15 p.m.
OAKENGATES
"How the Production Engineer Can be Helped by Research," by P. Spear. Shrewsbury Section. Walker Technical College, Oakengates, Shropshire. Wed., April 28, 7.30 p.m.
SHEFFIELD
"Some Aspects of the Study of Working Methods," by A. B. Armstrong. Sheffield Graduate Section. Sheffield College of Commerce and Technology, Pond-street, Sheffield. Mon., April 26, 7 p.m.

Institution of the Rubber Industry

BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Birmingham. Thurs., April 29, 6.45 p.m.
LIVERPOOL
Annual General Meeting. "Advertising," by T. G. Hartshorne. Merseyside Section. Electricity Supply Showrooms, Whitechapel, Liverpool. Mon., April 26, 7 p.m.
MANCHESTER
Annual General Meeting. Engineers' Club, Manchester. Mon., April 26, 6.15 p.m.

Institution of Structural Engineers

BIRMINGHAM
Annual General Meeting. "Some Factory Building Maintenance Problems," by W. T. Dudley. Midland Counties Branch. James Watt Memorial Institute, Birmingham. Fri., April 30, 6 p.m.
MANCHESTER
Annual General Meeting and Film Evening. Lancashire and Cheshire Branch. College of Technology, Manchester. Wed., April 28, 6.30 p.m.

Royal Aeronautical Society

LONDON
"Aerodynamics and Aero-Elastic Characteristics of the Crescent Wing," by G. H. Lee. Section Lecture. Tues., April 27, 7 p.m.
"Fuselage Structural Design Methods," by R. J. Jupe. Graduates' and Students' Lecture. Thurs., April 29, 7.30 p.m.

Royal Meteorological Society

LONDON
Annual General Meeting. Presidential Address on "The Development of Meteorology as an Exact Science," by Dr. O. G. Sutton. Wed., April 28, 5 p.m.

The Royal Society

LONDON
Discussion on "The First and Second Viscosities of Fluids," to be opened by Professor L. Rosenhead. Thurs., April 29, 2.15 p.m.

Royal Society of Arts

LONDON
"Official Printing and Typographical Design," by Harry G. Carter. Wed., April 28, 2.30 p.m.

Royal Statistical Society

LONDON
"The Outlines of the Roads Goods-Transport Industry," by K. F. Glover and D. N. Miller. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., April 28, 5.15 p.m.
LEICESTER
Annual General Meeting. Leicester Industrial Applications Group. Bell Hotel, Leicester. Thurs., April 29, 7 p.m.

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
Film Evening. Monday, April 26, 7.30 p.m.

Society of Instrument Technology

LONDON
"Instruments for Testing and Control in the Textile Industry," by S. L. Anderson. Manson House, 26 Portland-place W.1. Tues., April 27, 7 p.m.

Women's Engineering Society

LONDON
"Use of Models in Ship Design," by D. J. Doust. Tues., April 27, 7 p.m.
MANCHESTER
"Some Aspects of Marine Propulsion," by F. A. Fawcett. Engineers' Club, Manchester. Wed., April 28, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Supervising Electrical Engineers, 54 Station-road, New Barnet, Hertfordshire. (BARnet 9141.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Refrigeration, Dalmeny House, Monument-street, London, E.C.3. (MINcing Lane, 6851.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 36 Portman-square, London, W.1. (WELbeck 6813.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's-square, Sheffield, 1. (Sheffield 24071.)
Society of Instrument Technology, 55 Tudor-gardens, London, W.3.
Women's Engineering Society, 35 Grosvenor-place, London, S.W.1. (SLOane 0401.)